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THE CONDOR

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THE CONDOR

VOLUME 60 NOVEMBER-DECEMBER, 1958 NUMBER 6

BREEDING OF THE PARULA WARBLER AT POINT LOBOS, CALIFORNIA

By LAIDLAW WILLIAMS, KEN LEGG, and FRANCIS S. L. WILLIAMSON

This paper records the first known occurrence of the Parula Warbler (*Parula americana*) in California. It also describes the first two instances of nesting of the species in the state. Our records were made at Point Lobos Reserve State Park, just south of Carmel, Monterey County, on the coast of central California, in 1952. Although no specimen was taken at the time, identification as to species was made certain by numerous observations at close range. Identification in the field was corroborated by J. M. Linsdale, C. G. Sibley, and R. W. Storer, who also saw the birds during their period of breeding at Point Lobos in 1952. Because none of the birds was collected, it was deemed advisable to withhold a full account until evidence of the occurrence of the species in the state could be provided. The recent collecting of a Parula Warbler in California (Gould, 1957) now justifies the publishing of our purely observational account. We observed at least three individuals in Point Lobos Reserve State Park and just outside the park's eastern boundary almost daily from May 18 to July 16. Two nests were found, and it was ascertained that at least one young was fledged from one nest and two from the other.

The topography, habitat types, and vertebrate fauna of Point Lobos Reserve State Park have been described by Grinnell and Linsdale (1936). The park comprises 336 acres and encompasses the entire point of land, which projects about 1½ miles into the Pacific. "As at other places along the coast of central California the most noticeable climatic features at Point Lobos are the moderate temperatures, frequent fogs, and high winds" (*op. cit.*:7). The predominant forest growth consists of Monterey pines (*Pinus radiata*) frequently mixed with coast live oak (*Quercus agrifolia*). "An important feature of the forest here which owes its presence to nearness of the ocean is the abundant growth of lichens, especially *Ramalina reticulata*, which hang from the limbs of nearly all the trees" (*op. cit.*:16).

Initial observations.—The first observation of the species was made by Williamson who, on May 18, saw a male singing on the north side of Rat Hill, a pine-covered knoll within the park just south of its main entrance. On May 23, Williams and Legg, accompanied by R. W. Storer, saw two Parula Warblers on Rat Hill and heard one of them singing the characteristic song of the species, "a steady buzzy trill that rises in pitch and ends in a sharp slurred note" (song type "a" of Borror *in* Griscom and Sprunt, 1957:28). On May 26, Legg again heard the Parula Warbler on Rat Hill and saw a male in pursuit of a female. The birds were also watched in the same general area on May 27, 29, 30, 31, and on June 6. On June 8, a female was watched for ten minutes; it was foraging in a partially dead wild lilac bush (*Ceanothus thyrsiflorus*) on the southeast side of Rat Hill, near the place where nest number 2 was eventually discovered. Also, on June 8, Williamson heard a Parula Warbler singing for some time in the area in which nest number 1 was later found, across the highway paralleling the eastern boundary of the park, opposite Rat Hill. On June 9, a pair was seen in this latter area and watched for one hour and ten minutes. The male sang frequently and pursued the female. At

one time the pair perched on the mass of *Ramalina* which was later ascertained to be the site of nest number 1. We had no difficulty at any time in distinguishing male from female.

The nests.—Nest number 1 was situated outside the park, 80 yards east of the bordering highway. The nest tree, a Monterey pine, stood on a gently inclined northwest-facing slope; it was in a rather open stand of mature pines of this species, interspersed with a few coast live oaks, near the edge of a pasture. There was a rather dense but low understory of coffeeberry (*Rhamnus californica*), poison oak (*Rhus diversiloba*), and blackberry (*Rubus vitifolius*), with some wild lilac, bush monkey flower (*Diplacus aurantiacus*), and snowberry (*Symphoricarpos mollis*).

The nest was situated in a mass of *Ramalina* which was hanging from twigs about 10 inches in from the tip of a limb 10 feet long, growing in a westerly direction from the trunk, at a height of about 30 feet (fig. 1). Except for a few twigs which had live needles, the limb bore only dead branchlets. Almost all of the pines in the vicinity of the nest tree had some lichen streamers on their branches. The chosen nest site, however, was in a mass of lichens which was noticeably thicker and more extensive than those on the other trees, or on the other branches of the nest tree.

Because of its situation, the nest was inaccessible for close inspection. After the young had been fledged, however, the nest limb was cut down. It was then found that the nest consisted of a rather thick-walled, loosely constructed cup, the bulk of which was composed of strands of *Ramalina reticulata*, scantily lined with grasses (?) and a few horse hairs. Visible on the rim and outside edge were several tufts of plant down and a thistle achene. The nest measurements in centimeters were as follows: inside diameter, 3.5–4.0; outside diameter, 6.5–7.0; inside depth, 3.2; outside depth, 4.2. The nest cup was fastened at the bottom to, and stood up from, masses of lichens. These lichens were attached to twigs a few inches above and on either side of the cup rim. Whether these hanging skeins supporting the cup had been woven together by the bird to form the support, or whether they had grown together in this hammock-like formation in the course of their naturally reticulate development, was not definitely determined by us. However, in the field on June 10, we noticed that some strands beneath the area where the nest cup was later known to be situated, instead of hanging directly downward, as were the strands on either side, seemed to have been looped up, as though by action of the bird. The warbler had made an entrance through the lichen mass slightly above and to one side of the nest rim, toward the distal end of the branch.

About fifty-seven hours were spent observing the activities of the Parula Warblers at, and in the vicinity of, this nest, from June 9 until July 16, the third day after a young bird was first seen out of the nest. Nest building may have been under way when the site was first discovered by us. From June 10 to 14, the female made frequent trips to the nest. On some of these trips, she could be seen bearing small bits of material which seemed to be plant down. During periods when the female was in the nest, the whole lichen mass would often vibrate violently and appear to be manipulated from within. Since the bulk of the nest cup was made of *Ramalina* strands, and since we did not observe the transport of such material, we though it possible that these violent motions of the lichen mass, although perhaps caused only by "molding actions," may actually have been due to the pulling loose of strands from the festoon itself and the arranging of them into the nest cup on the spot. After retrieving the nest, we found that it was possible to tease out a strand of lichen and trace it back to the supporting curtain, indicating that the bird had actually followed this procedure. On June 11, a definite silhouette of what proved later to be the nest cup could be seen through the lichen curtains. At 7:21 a.m. on that day, after the female had entered the nest, one of us (Williams)

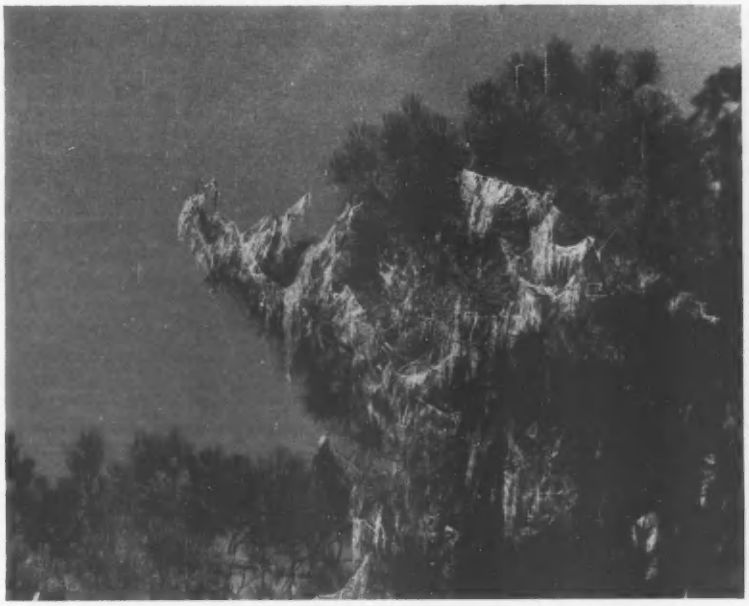

Fig. 1. Site of nest number 1 of Parula Warbler (*Parula americana*), Point Lobos Reserve State Park. Nest was placed in *Ramalina reticulata* hanging from a Monterey pine.

saw her head and bill appear at the nest entrance, at which time she briefly arranged a strand of lichen.

From June 9 to 24, the male was seen and/or heard in the vicinity of nest number 1 on each of the 13 observation days in this period, except on June 19 and 20, when only 15 minute checks were made. Singing was frequently heard within a radius of about 240 feet of the nest tree. The bird sang both the type "a" and type "e" songs of Borror (*in* Griscom and Sprunt, 1957:28) together with what seemed to us to be a variation of type "e." The male accompanied the female on her return trips to the nest at least once per day on June 9, 10, 14, 17, 22, and 24. On these occasions, he often alighted on the nest limb with his mate, but after she had entered the nest he flew off. He was never seen to carry nest material or to enter the nest festoon proper.

After June 24, no male was seen again at the nest tree, nor was any heard singing within a radius of 240 feet. Incubation and the care of nestlings and fledgling(s) were accomplished by the female alone. Incubation was assumed to have begun not later than June 22, to judge by the rhythm of the female's periods on and off the nest.

On July 3, we observed food being taken to the nest for the first time. On July 12, food was still being taken to the nest and only to it. On July 13, a fledgling was seen. It was close to the ground in a *Rhamnus* thicket near the base of the nest tree. The female fed this fledgling, but she also continued to feed at least one nestling whose food calls could still be heard from within the nest. On July 14, in one hour of observation, only one fledgling could be seen. All food was taken to this young bird (18 feedings), except on the occasion of one trip by the female to the nest when it was thought that she

might have fed a nestling from the nest entrance, although no food calls were heard from within. On July 15, no trips to the nest were observed and all food was brought to one fledgling near the base of the nest tree (34 feedings in one hour).

A thorough search of the nest area was made on July 16, but no fledgling could be found. The female, however, was in the immediate area and was carrying food, but she was never seen to deliver it, nor could the food calls of any young be heard. It was presumed, therefore, that although at least one young bird had left the nest on July 13, neither this fledgling, nor its siblings, survived after July 15. Nothing further was known of the female after July 16.

Nest number 2 was situated within the park on the south side of Rat Hill, 145 feet west of the highway and 556 feet southwest of nest number 1. The nest tree was a much smaller Monterey pine than that of nest number 1, and it was growing in a somewhat denser stand of pines. The rather sparse undergrowth consisted principally of a few small, scattered live oaks, some poison oak, and a few wild lilac bushes.

The nest was suspended within a long festoon of *Ramalina* which was hanging from a drooping dead branch and was 15 feet above the ground (fig. 2). An entrance had been made by the birds through an opening at one side on a level with the rim of the nest cup, which was just out of sight behind the curtain of lichens. A twig across the threshold of the opening served both as a partial support for the nest and as a perch for the entering birds. However, it was impossible to determine whether the lichen material of the cup walls was drawn from the surrounding strands of the festoon, or whether it was brought in from elsewhere. The cup was thinly lined with unidentifiable flowering plant material. The nest measurements in centimeters were: inside diameter, 4.0; outside diameter, 6.0–6.5; inside depth, 3.3; and outside depth, 5.5.

The nest was not removed, but, after the fledging of the young, it was examined from a ladder. It then became obvious that at this nest site many of the outer strands of the festoon had been looped up and tucked in to form a foundation under the bottom of the cup. On July 2, the female was seen on three occasions pulling, or arranging, lichens at the nest entrance.

Legg discovered this nest on July 1, five days before the fledging of the young. Eighteen hours and twelve minutes were spent observing the activities of parents and young, at and near the nest, from July 1 through 13, the seventh day after the second of the two fledglings had left the nest.

On July 1 and 2, both parents were caring for the young, the female feeding and brooding, the male feeding the young and singing frequently. The male's rate of feeding the nestlings exceeded that of the female on both days. Both parents removed excreta. On July 3, no observations were made. On July 4, the female was not seen, nor was she seen again thereafter. Her disappearance took place sometime between 6:48 p.m. on July 2 and 6:06 a.m. on July 4. The male, however, continued to feed the young unaided.

On July 4, the male was still feeding the nestlings. On July 5, he fed one fledgling, which left the nest sometime between 8:15 and 10:21 a.m., but he also fed at least one young which remained in the nest until 4:35 p.m. or later. On July 6, two fledglings were seen, one about 100 feet from the nest, the other only 8 inches above the nest entrance. The male fed both of these but was not seen to make any trip to the nest. It was therefore concluded that at least two young had been fledged.

The male was last seen on July 13 as he was feeding two fledglings which were fairly high up in trees about 40 feet apart and at a maximum distance of 150 feet from the nest. One young could be examined well enough to note an advance in the growth of the rectrices since the fledging date, one week previously. The growth stage of these fledglings was definite evidence that neither was from nest number 1.

Fig. 2. Female at entrance to nest number 2 of Parula Warbler, Point Lobos Reserve State Park, July 1, 1952. Nest was placed in festoon of *Ramalina reticulata* in Monterey pine.

With regard to the time of breeding at Point Lobos compared to the time of breeding in the normal range, Wilde (1897:291) states that in New Jersey the species starts nest building by the second week in May. Full clutches of fresh eggs may be found on May 20, and on June 4, 1893, Wilde found a nest containing young (*op. cit.*:294). Mousley (1926, 1928) observed nests being built in Quebec between May 25 and 28, 1924, and May 22 and 31, 1925. He watched a nest with young between June 13 and 19, 1921 (Mousley, 1924). In their brief study of four nests in Michigan, Graber and Graber (1951) found one nest in the building stage on July 11. In two nests, the clutches of three eggs each were completed on July 13 and 14. In one nest, the two young fledged on July 3, and in another the single remaining young left the nest prematurely on August 4.

The Parula Warblers at Point Lobos were later in their breeding than were the birds in New Jersey and Quebec, but they were earlier than the birds in Michigan with the exception of the brood of two which left the nest on July 3, three days prior to the leaving of the brood from nest number 2 at Point Lobos.

Status of the male(s).—Although two breeding females were found at Point Lobos in 1952, not more than one male was seen positively at one time. In the period June 9–24, the male in attendance at nest number 1, after accompanying the female as she returned to enter the nest, first sang nearby and then often made his way westward (as we could deduce from his constant singing) toward Rat Hill, the location of nest number 2. Conversely, after an absence from nest number 1, songs could be heard coming from the direction of Rat Hill, at first in the distance, then near at hand, until he reappeared near nest number 1. On June 14, 16, and 18, when the observer (Williamson) was at a place about equidistant between the two nests, singing was heard coming from the Rat Hill area and then progressing toward nest number 1. There was no indication that any of this singing was produced by more than one bird. On June 14, Williamson summarized his watch at nest number 1, in part, as follows: "The male divides his time between Rat Hill and the nest tree, never moving far to the east."

When nest number 2 was discovered on July 1, 5 days before fledging, both a male and a female were feeding nestlings. On four of these days (July 1, 2, 4, and 5), observers were stationed at the two nests simultaneously for a period of 5 hours and 7 minutes. No male was seen during this period at nest number 1, in which at least some of the young had hatched by July 3, nor did any male reappear there throughout the remaining 13 hours and 27 minutes of observations of the nestling and fledging periods. Singing was not heard closer than about 240 feet west-southwest of this nest, and none of the songs heard was other than those that could have been produced by the male in attendance at nest number 2. This male sang frequently between feedings of nestlings. Because nest number 2 was not discovered on Rat Hill until July 1, the degree of male attention to that nest before that date must remain a matter of conjecture. However, the presence of at least one male in the Rat Hill area was obvious from the beginning of our observations.

We therefore believe it highly probable that, although at first there may have been two males at Point Lobos, only one male was present after June 10. It may be that this male was polygynous, dividing his attention between the female of nest number 1 and the Rat Hill area. But on June 25 or 26, he abandoned the female of nest number 1 and focused his attention on nest number 2.

In a discussion of behavior patterns in the Parulidae of both North and Central America, Skutch (1954:384) states that "polygamy rarely occurs in the family; but in the Oven-bird [*Seiurus aurocapillus*] Hann (1937:155) found two instances of males with two mates . . . ." Van Tyne (*in* Griscom and Sprunt, 1957:179) records an instance of polygyny in the Kirtland's Warbler (*Dendroica kirtlandii*). These cases of polygamy were detected in studies in which color bands were used. Few other species of the family have been investigated extensively by this method. Cases of bigamy have been recorded in usually monogamous species of other passerine families. These occur when a female, widowed in the breeding season, is taken on as a second mate by a neighboring male (Nice, 1937:88–89; Blanchard, 1941:19).

Survival.—If we assume that 4 adults, two males and two females, were present at Point Lobos in the early part of this study, then one of these males must have disappeared about June 10. Between July 2 and 4, the female from nest number 2 disappeared during the fledging period of her young. It is believed that no young from nest number 1 survived after July 15, two days at the most after fledging. Two young from

nest number 2, in the care of the male only, survived at least until July 13, seven days after fledging. Nothing further was known of the Parula Warblers after female number 1 was last seen on July 16. Assuming that the male and his two young were alive at least until July 16, then only two adults and two young had survived up to that date.

In 1953, the year following the appearance of the species at Point Lobos, two of us (Williams and Legg) made a number of searches, both in the study area and in other lichen-draped pine woodlands of the adjacent Monterey Peninsula region in May, June, and July, but no Parula Warbler was found, nor has any been recorded subsequently.

DISCUSSION

The American Ornithologists' Union (1957:485–486) delimits the western boundary of the normal breeding range of the Parula Warbler as extending from Winnipeg, Manitoba, south to Kerrville, Texas, and cites only one record of casual occurrence for any locality west of the Rocky Mountains and the southwestern deserts. This was a male taken at San Xavier Mission, Arizona, on March 26, 1938 (Monson, 1942). There is another record for Arizona, a female seen near Tucson on December 28, 1940 (Monson, *loc. cit.*). But we could find no other published record of penetration into, or west of, the Rocky Mountain-Sierra Madre Occidental axis until 1952, the year of their occurrence at Point Lobos Reserve State Park.

In 1952, there were two, or possibly three, cases of western occurrence in addition to the one which is the subject of this paper. On May 24, 1952, a male "in full song" was taken in Gunnison Valley, elevation 7800 feet, Colorado (Hyde, 1953); a "singing male of the genus *Parula*" was seen at Roosevelt, Arizona, on May 31, 1952 (Monson, 1952); and a "pair" was taken in riparian woodland in the Sierra de Los Ajos, in northeastern Sonora (J. T. Marshall, 1957:108). In the latter instance, a male with enlarged testes was collected on July 16, 1952, and a female with an old brood patch was collected at the same site on July 29, 1952. In none of these cases, however, was actual breeding observed. The record from Point Lobos is therefore the first instance of the breeding of the Parula Warbler west of the breeding range as outlined by the American Ornithologists' Union (1957). It is also the first occurrence of the species on the Pacific coast north of México. The next occurrence of the species in the west coastal region of the United States was the collecting of a male 11 miles east of Palm Springs, Riverside County, California, on April 29, 1956 (Gould, 1957).

It has been suggested that the Parula Warblers that appeared at Point Lobos in May, 1952, had been "wind-drifted" from their normal spring migration route (Peterson and Fisher, 1955:311). In this connection, it should be noted that another "displaced" parulid, an Ovenbird, was seen by Williams at Carmel Highlands, about one mile from Point Lobos, on May 31, 1952, the first record of the species in Monterey County. This warbler is considered a rare migrant in California by Grinnell and Miller (1944:408–409), who list three specimens and one sight record for the state. Although the Parula Warblers and the Ovenbird may have reached the central coast of California as a result of the same factor or factors, we have made no attempt to correlate the appearance of these birds in our area with any meteorological phenomenon, and we can offer no suggestion as to why they appeared.

Grinnell (1922:374), commenting on the role of the "accidental" as it applies to the avifauna of California, makes a brief for the concept that "the occurrence of individual birds a greater or less distance beyond the bounds of the plentiful existence of the species to which they belong is the *regular thing, to be expected*. There is nothing really 'accidental' about it; the process is part of the ordinary evolutionary program." In further discussion of pioneering individuals, Grinnell (*op. cit.*:377–378) points out that "the

vast majority of such individuals . . . are foredoomed to early destruction without any opportunity of breeding . . . . In the relatively rare case two birds comprising a pair . . . may even stumble upon a combination of conditions in a new locality the same as in its parent metropolis, and there start a new detached colony of the species."

Although no permanent "colony" was established at Point Lobos, since no repetition of breeding, or even of occurrence, has been recorded in subsequent years, at least three Parula Warblers, diverted far westward by unknown causes in 1952, happened to "stumble" upon environmental conditions which were, at least in part, congenial to them there. Disregarding any other possible factor, or factors, it is suggested that the birds at Point Lobos found an element among the physical features of the environment which stimulated breeding responses. This element was probably *Ramalina reticulata* in abundance. *Ramalina* in superficial appearance and drooping manner of growth, resembles the usual nest site requirement of the species over most of its normal breeding range, in other words, the "beards" of the lichen *Usnea* in the northeast, and the flowering plant, "Spanish moss" (*Tillandsia* sp.), in the southeast (Chapman, 1907:103–109; Bent, 1953:135–149; Griscom and Sprunt, 1957:97–98). Further, in the lower Mississippi Valley, Parula Warblers have been stated to breed in many localities in which *Usnea* is largely or entirely replaced by species of *Ramalina* (Ridgway, 1902:486, footnote).

At Point Lobos, the Parula Warblers encountered little, if any competition for nest sites. None of the breeding birds there uses exclusively lichen festoons for nest emplacement or support. According to Grinnell and Linsdale (1936:16–17), a majority of nests in this area are composed mainly of strands of *Ramalina reticulata*, especially the nests of the Common Bushtit (*Psaltriparus minimus*), Hutton's Vireo (*Vireo huttoni*), and House Finch (*Carpodacus mexicanus*). However, the Common Bushtit was the only species that utilized lichen festoons for nest sites, and it did not make use of them frequently. Of the 21 nests of that species at Point Lobos described by these authors (*op. cit.*:93–94), only three were built in lichen masses. Aggressive encounters were noted between the Parula Warblers and five other species: Allen's Hummingbird (*Selasphorus sasin*), Western Flycatcher (*Empidonax difficilis*), Western Wood Pewee (*Contopus sordidulus*), Chestnut-backed Chickadee (*Parus rufescens*), and Wilson's Warbler (*Wilsonia pusilla*). However, none of these species could be considered a nest site competitor of the Parula Warblers.

With regard to the actual construction of the nests which we observed, it should be noted that Parula Warblers, in their normal breeding range, utilize several different types of nest construction, ranging from nests which are situated independently of the festoon of lichens or *Tillandsia* (Brewster, *in* Bent, 1953:139; Mousley, 1926:185–187) to nests which are situated within the festoon proper (Thayer, *in* Chapman, 1907:107; Wilde, 1897:292; Graber and Graber, 1951:75, 78). Indeed, some nests are built in areas completely devoid of either *Usnea* or *Tillandsia* (Petrides, 1942; Nice, *in* Bent, 1953:140; Peterson, 1946:197; Cunningham, 1947:158; Schwilling, 1951). Our nest number 1 appears to resemble the "suspended basket" type of construction described by Thayer (*in* Chapman, 1907:78). Nest number 2 resembles in most respects the suspended structures described by Wilde (*loc. cit.*) and Graber and Graber (*loc. cit.*). In short, the nest materials and types of nest construction used by the Parula Warblers at Point Lobos fall within the range of variation for these aspects of nest building demonstrated by the species in its normal breeding range.

Thus, it seems likely that the breeding of the warblers at Point Lobos resulted from two main factors. First, individuals of both sexes appeared at this extralimital locality

at a time of year when the active phase of the reproductive cycle would be under way, in the male at least. Second, the birds came to an area of moderate climate in which familiar nest sites and nest materials were present. It may be that the presence of these necessities, and the presence of a sexually active male (or males), stimulated the reproductive physiology of the females to the point of actual nesting. Although the male enters full breeding condition apparently through the stimulation of increasing day-length, there is some evidence suggesting that the attainment of full reproductive capacity by females is dependent, at least in part, on the presence of a sexually active male, proper nest sites, nest materials, and an adequate food supply for the young (see, for example, Burger, 1949; A. J. Marshall, 1951). We suggest that the situation at Point Lobos involved the presence of Parula Warblers of opposite sex in an area which, although far from the normal breeding range, fulfilled the breeding requirements of the species.

SUMMARY

The first known occurrence of the Parula Warbler in California was recorded at Point Lobos Reserve State Park, Monterey County, on May 18, 1952, when one male was seen. Between May 18 and July 16, two females and at least one male were observed. This was the first record of the species west of the Rocky Mountains and the southwestern deserts.

Two nests were found. Both were situated in festoons of the lichen *Ramalina reticulata*, hanging from Monterey pines.

At least one young was fledged from one nest, and two young were fledged from the other. The young from one nest apparently did not survive beyond the second day after fledging. At the other nest, the two young were known to have survived at least eight days after fledging.

Our observations suggested that, although two males might have been present at the beginning of our study, one disappeared and the other was believed to have become polygynous.

It is believed that, other conditions being suitable, the fortuitous occurrence of individuals of both sexes in an area in which an abundance of lichens hanging from trees provided nest sites and materials similar to those used in the normal breeding range of the species induced breeding in these birds.

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Carmel, California; Eureka, California; and Anchorage, Alaska, August 13, 1958.

AGE DETERMINATION AND MOLT IN THE BOAT-TAILED GRACKLE

By ROBERT K. SELANDER

The success of behavioral, gonadal, systematic, and other studies of birds may depend on proper segregation of individuals into age classes (Pitelka, 1945; Davis, 1957). This study concerns criteria of age in the Boat-tailed Grackle (*Cassidix mexicanus prosopidicola*) derived from examination of specimens from central Texas. Special attention is given to criteria by which first-year and adult birds can be distinguished, in order to compare the annual reproductive cycles of these two age groups (Selander and Hauser, MS). The investigation is also designed to serve as groundwork for the author's comparative studies of behavior and phylogeny in the grackles.

The present study is based on 328 males and 165 females collected over a 16-month period in 1956 and 1957, within a ten-mile radius of Austin, Travis County, Texas. Specimens were processed as follows: The left testis or ovary was removed and placed in Bouin's fixative in preparation for histologic studies; body weight was recorded (within two hours after death); extent of molt, if any, was recorded in detail for each feather tract and its regions; types and numbers of juvenal feathers retained through the postjuvenal molt by first-year individuals were noted; extent of skull ossification was determined; iris color was recorded; relative amount of body fat was noted; and measurements of wing, tail, bill, tarsus, and middle toe were taken. Approximately 10 per cent of the specimens were prepared as study skins or skeletons and deposited in the Texas Natural History Collection.

Age determination of males presents relatively few problems. First-year males are duller and less glossy or iridescent than adult males and generally can be recognized at a glance (fig. 2). The duller color, in combination with a shorter and narrower tail, is generally so conspicuous that first-year birds are recognizable in the field. Care must be exercised in individual cases, however, because some first-year males are nearly as iridescent and dark as adults, particularly after the prenuptial molt, and have adult-like tails.

Age determination of females is a much more difficult problem and cannot be accomplished with certainty on the basis of plumage color alone. In worn plumage, color is of little value in age determination. In studying the race *C. m. monsoni,* Phillips (1950) had only limited success in aging female museum specimens, and he stressed the need in taxonomic studies for females of known age.

The need to establish criteria by which first-year and adult females can be identified with confidence and to test the validity of plumage color as an age criterion in males has necessitated a detailed investigation of molt. Characters other than color that were examined for use in determining age are feather shape and degree of wear, retention of juvenal feathers through the postjuvenal molt, iris coloration, degree of skull ossification or double layering, and size. Using a combination of characters, it has been possible to age all specimens collected. Some characters are of value not only in *Cassidix* but in related genera of icterids as well.

MOLTS AND PLUMAGES

The plumages of *Cassidix m. major* were described in part by Ridgway (1902) and McIlhenny (1937), but the present findings for *C. m. prosopidicola* necessitate some further comment on this subject. Other than a few notes by McIlhenny (*op. cit.*) and Dwight (1900), apparently nothing has been reported concerning molt in this genus.

Pterylography of the wing.—In the following accounts of molts and plumages, the nomenclature of feather tracts and their regions employed by Pitelka (1945) in his

study of jays of the genus *Aphelocoma* has been adopted in so far as possible. Because there are major differences in pterylography of the alar tract between corvids and icterids, the following notes are provided as background for discussions of molt and retention of wing feathers by first-year birds.

In *Cassidix*, there are 9 primaries and 9 secondaries. A small feather representing either a vestigial tenth primary or a tenth primary covert is found distal to and in line with the ninth primary; this feather is approximately the same size as the ninth upper

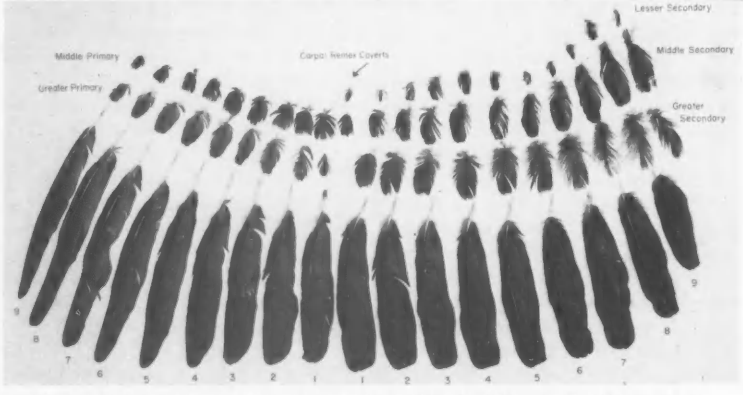

Fig. 1. Remiges and under coverts from right wing of adult male *Cassidix mexicanus*, arranged to show principal series.

greater primary covert. It molts with or immediately after the ninth primary and its coverts, not with the adjacent marginal coverts with which it might be confused.

On the under side of the wing (see fig. 1), the primaries have complete series of 9 under greater primary coverts and 9 under middle primary coverts. The latter are darker, wider, and shorter than the former. The first under greater primary covert is small, being one-half the size of the second. Under lesser primary coverts are not represented. There are series of 10 under greater secondary coverts, under middle secondary coverts, and under lesser secondary coverts. The under middle and lesser secondary coverts are darker than the greater, and the under lesser secondary coverts show considerable individual variation in size. At the distal ends of the series of under middle and lesser secondary coverts there occur an extra middle and lesser covert representing the coverts of the carpal remex.

Viewed ventrally the under greater primary and secondary coverts are slightly concave in shape, as are the primaries and secondaries; in contrast the coverts of the under middle primary and under middle and lesser secondary series are slightly convex.

In the wing dorsally, there are 9 upper greater primary coverts; the ninth is small and lanceolate, being approximately one-half as long and less than one-fourth as wide as the adjacent eighth covert. Only 8 very small upper middle primary coverts are present; the first is absent and its position is occupied by the carpal remex. There are 10 upper greater secondary coverts and 8 upper middle secondary coverts; a ninth upper middle secondary covert is absent. The carpal remex has a small covert which is in line with but smaller than the adjacent covert of the upper middle secondary series. As in *Aphelocoma* (Pitelka, 1945:232), there is a small covert lying between the covert of the carpal remex and the base of the innermost of the three feathers of the alula. Neither

primaries nor secondaries have upper lesser coverts.

Along the posterior, distal margin of the humeral region there is a series of 8 vestigial tertiaries. Proximally, this series grades into the humeral tract proper, and the distalmost feather of the series is inserted only 3 mm. proximal to the tenth upper middle secondary covert.

The pterylography of the wing is essentially similar in the related genera, *Quiscalus, Holoquiscalus, Euphagus, Molothrus, Tangavius,* and *Agelaius.* In *Quiscalus, Molothrus* and *Agelaius,* as in *Cassidix,* first-year birds frequently retain juvenal under wing coverts and some tertiaries through the postjuvenal molt. Whether this occurs in the other genera remains to be determined. Dwight (1900:159) and subsequent authors were in error in reporting that the postjuvenal molt of *Molothrus* and *Quiscalus* is complete. In *Molothrus* not uncommonly all under coverts and some long marginals on the leading edge of the patagial membrane are retained.

Juvenal plumage.—In this plumage, both sexes are buffy brown ventrally and the breast, abdomen, and flanks are irregularly streaked and blotched with dark brown or black (figs. 2 and 3). Dorsally, the birds are darker brown; the flight feathers are dull brownish black. McIlhenny (1937:275) reported that in *C. m. major* the juvenal plumages of males and females are identical, but juveniles of *C. m. prosopidicola* may easily be sexed on the basis of color differences alone. In juvenal males, the ventral dark streaking or blotching is darker and the individual streaks are much wider and, hence, more conspicuous than in juvenal females. Elsewhere in the plumage the brown color is darker (more blackish). A week after hatching, males are larger than females, and by the time of fledging the size difference is very conspicuous.

It seems probable that McIlhenny (1937:275) confused the terminal stages of development of the juvenal plumage with the onset of the postjuvenal molt. With reference to the supposed inception of the postjuvenal molt, he stated that "within a few days after leaving the nest, the young males begin to show a few dark feathers around the eye . . . ," and he claimed that feathers around the eye and on the anterior part of the crown "are the first to show the change from nestling [juvenal] to the first-year . . . plumage." In *C. m. prosopidicola,* at least, and probably within the species generally, the situation is different. The feathers around the eye in juvenal males which are darker than those of adjacent regions are late-developing feathers of the juvenal plumage. In nestlings, the eye region is naked or nearly so, and the appearance of feathers in the superciliary, ocular, loral, and anterior auricular regions is delayed until most other parts of the juvenal plumage are well grown. A similar condition is recorded for *Molothrus ater* (Friedmann, 1929:278) and is found also in *Holoquiscalus niger* (Selander, MS). These late-developing feathers are replaced in the postjuvenal molt but not until well along in the molt. They are dull brownish black and not easily confused with the more or less glossy black feathers of the first-year plumage which subsequently replace them.

Development of the juvenal under wing coverts also is delayed. At the time of fledging and for a period of several days thereafter, the juvenal under wing coverts are still growing. Generally they are darker and glossier than other contour feathers of the juvenal wing and, on this account, may be rather conspicuous. In some birds, there are a few dark feathers among the brown wing coverts, particularly near the bend of the wing. Usually some tertiaries and some late-developing feathers of the humeral tract, and, less frequently, the interscapular region are conspicuously darker than the other feathers, being about intermediate between other juvenal feathers and those of the first-year plumage. It is apparent that in late stages of development of the juvenal plum-

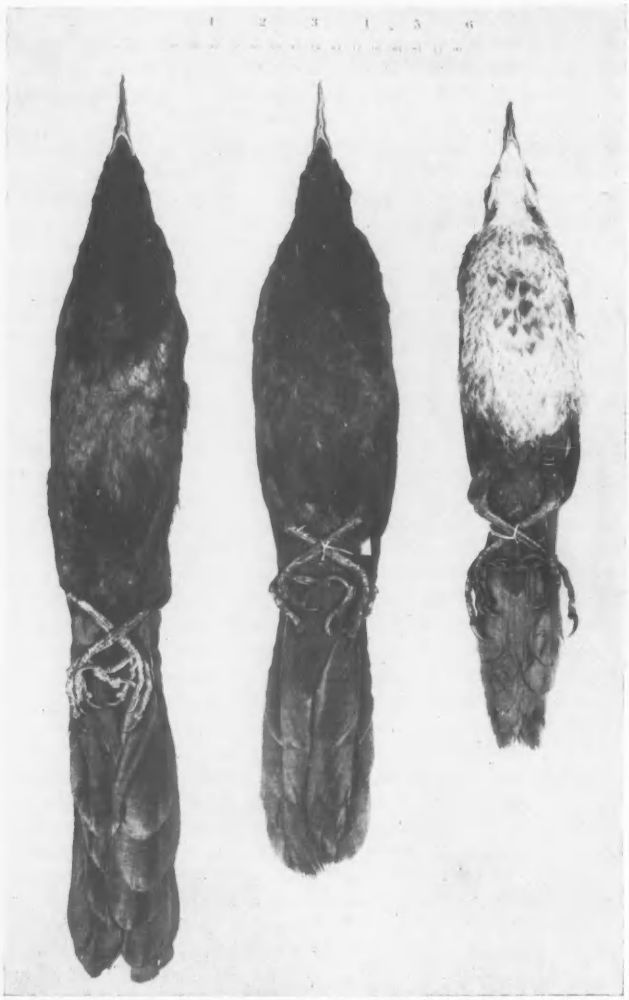

Fig. 2 Male specimens of *Cassidix m. prosopidicola* in ventral view. From left to right: adult, first-year, and juvenile.

age the color of incoming feathers depends, to some extent at least, on the degree of physiological maturity attained by the bird at that time. The presence of dark or semi-glossy feathers in juvenal males should not be mistaken for early inception of the post-juvenal molt. In the postjuvenal molt, most of the above mentioned late-developing feathers are replaced; the marginals and the head, interscapular, and humeral regions are completely replaced, but some tertiaries and under wing coverts usually are retained (see beyond).

Late appearance and precocious color development in juvenal marginals and late development of under wing coverts occurs also in *Aphelocoma* (Pitelka, 1945:234–235).

Postjuvenal and postnuptial molts.—In *Cassidix mexicanus*, the postjuvenal molt usually is incomplete, some or all juvenal *under* greater primary and secondary coverts and some juvenal feathers at the posterior margin of the humeral tract being retained.

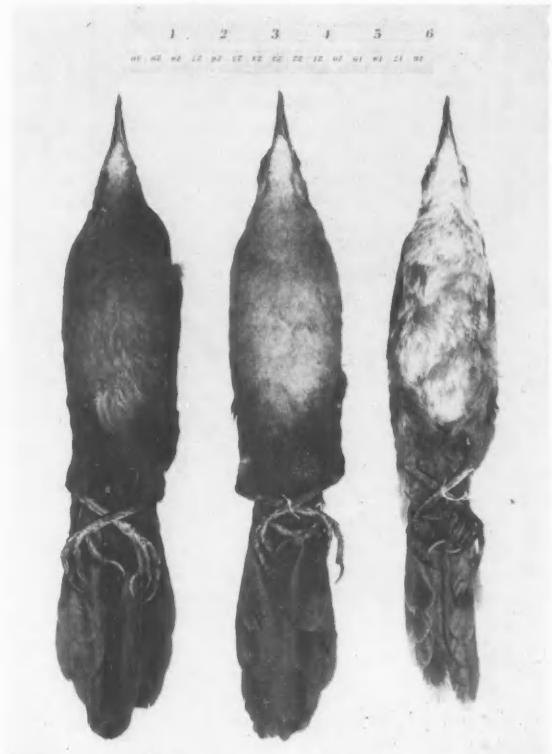

Fig. 3. Female specimens of *Cassidix m. prosopidicola* in ventral view. From left to right: adult, first-year, and juvenile.

With rare exception all other juvenal feathers, including rectrices, remiges, alula, and upper wing coverts are replaced. Aside from this feature, the postjuvenal molt is similar to the postnuptial molt and it is convenient to discuss the two together.

Inception of molt.—Both the postjuvenal molt and the postnuptial molt begin with the approximately simultaneous loss of primary 1 and its upper greater primary covert and the appearance of new glossy black marginal feathers immediately posterior to the bend of the wing. Shortly thereafter and at about the time primary 1 is one-third grown, the entire series of upper greater secondary coverts and the carpal remex are dropped, followed shortly by the series of upper middle primary coverts. Upper middle secondary

Table 1

Stages of Fall Molt in *Cassidix mexicanus*

Stage number	1	2	3	4	5	6	7	8
Primaries	1–2 dropped or growing but short	1–3 almost fully grown; 4 partly so	1–4 fully grown; 5 well grown; 6 dropped	7 dropped or partly grown; 6 partly grown; 8–9 old	8 partly grown; 9 old or dropped	9 one-fourth grown; 8 well grown	9 ⅘ or more grown, or ensheathed basally	Growth complete
Secondaries		Old or 1 and/or 8 dropped	1 fully grown; 2 three-quarters grown; 3 dropped; 4–7 old; 8 three-quarters grown; 9 dropped	3–6 old; 7 dropped	5–6 old; 3 and 4 well grown	6 old or partly grown; 5 well grown	6 ¾ or more grown, or ensheathed basally	Growth complete
Upper greater secondary coverts	Old or all dropped or breaking sheaths	One-half grown	Fully grown but ensheathed basally	Growth complete				
Alula				Old	Old or dropped	½ to ¾ grown	Growth complete	
Rectrices			Old	Dropped	One-fourth or less grown	One-half to three-quarters grown	1–3 ensheathed basally or 1–1 ⅘ grown	Fully grown except 1–1
Capital tract, dorsally		Old	Some new feathers evident	Feathers mostly old	Coronal and occipital regions one-half grown	Coronal and occipital regions refeathered; frontal reg. ¾ grown	Growth complete or few feathers growing in frontal region	
Capital tract, laterally		Old	Some new feathers evident	Feathers old or one-fourth grown	One-half grown	Three-quarters grown	All feathers at least four-fifths grown	Few feathers not fully grown
Spinal tract		Old or a few new feathers evident	One-half grown centrally	One-half grown throughout	Interscapular and cervical regions one-half grown; pelvic and dorsal regions three-quarters grown	All feathers new and at least three-quarters grown	Pelvic and dorsal reg. refeathered or few feathers growing in pelvic reg.; feathers of interscapular and cervical reg. ⅘ grown	Growth complete
Tail coverts		Old	Less than one-fourth grown	One-half to three-quarters grown	Growth complete			
Ventral tract		Old or some new feathers evident on breast	One-fourth replaced	One-half replaced centrally; old elsewhere	Old to three-quarters grown	Three-quarters to fully grown in most areas	Interramal region ¾ or more refeathered	Interramal reg. not fully refeathered

coverts are not replaced at this time, and upper greater primary coverts continue to molt one at a time with their corresponding primaries. By the time primary 3 is growing, molt has spread from the marginals at the bend of the wing to the more distal and proximal marginals dorsally and ventrally. Molt in the dorsal region of the spinal tract and sternal region of the ventral tract begins at about the time primary 5 is developing. Molt on the head is invariably initiated at a locus in the occipital region when primary 7 is developing and later spreads forward to other regions of the head dorsally.

The rectrices are lost as a unit at about the time primary 9 is dropped and after the tail coverts have been renewed. Thus the birds are tailless or bobtailed for about two weeks in the latter part of the molt period. Simultaneous molt of the rectrices in *C. m. major* was reported by McIlhenny (1937:276, 292).

Molt categories.—A total of 125 males and 79 females in fall molt was examined; this includes 41 males in postnuptial molt and 84 males in postjuvenal molt. Following detailed examination of each specimen, a series of 8 arbitrary stages of molt progress was established to permit comparisons of timing of molt in different sex and age groups in the two years (1956 and 1957) in which molt was studied. The stages (table 1) correspond in a general way to those defined for the postnuptial molt in *Aphelocoma coerulescens* by Pitelka (1945). However, some major differences will be apparent, mainly because *Aphelocoma* has 10 primaries, whereas *Cassidix* has only 9. By assigning specimens to intermediate categories, the total number of available categories was increased to 15. Each molting bird was assigned to a category and the resulting scores were plotted against time of collection in figure 4. A summary of information on timing of molt appears in table 2.

Technically, molt is not completed until the individual has passed through stage 8 and has replaced all feathers. However, for purposes of determining duration of periods of molt in individuals and in the population, birds in stage 8 are considered to have completed the molt. The amount of feather growth occurring after the time of completed growth of primary 9 and secondary 6 is relatively insignificant.

Preliminary plottings showed an absence of significant difference in timing of molt in 1956 and 1957, notwithstanding the fact that, at least for a sizable part of the adult and first-year population, the breeding season was shorter in 1956 than in 1957. In 1956 only a single brood was raised and both males and females were freed from duties connected with breeding at an earlier date than in 1957 (Selander and Hauser, MS). In figure 4, data for the two years are combined.

Molt in males.—From July 9 to October 17, all adult males collected were in molt. From figure 4, it can be estimated that the period of postnuptial molt in individual males lasts from 15 to 16 weeks or 105 to 110 days. The first adult male to complete the postnuptial molt was collected on October 17; but on the average adults complete their molt somewhat later, in the first week of November.

The data suggest that males undergoing their first postnuptial molt begin a few days earlier than older birds. Three year-old males taken between July 7 and 17 were in stages 1½ or 2, whereas three older adults collected in the same period were in stages 1 or 1½. Because the age of specimens in later stages of postnuptial molt was not determined, this problem cannot be pursued further, but it may be noted that Pitelka (1945, 1958) has demonstrated early postnuptial molt in year-old jays of the genera *Aphelocoma* and *Cyanocitta*.

Postjuvenal molt is characterized by irregularities and by great individual variation in timing, as reflected by the wide spread of categories represented by specimens taken on any one date.

Juveniles may begin molting on the average several days before adults. Three molt-

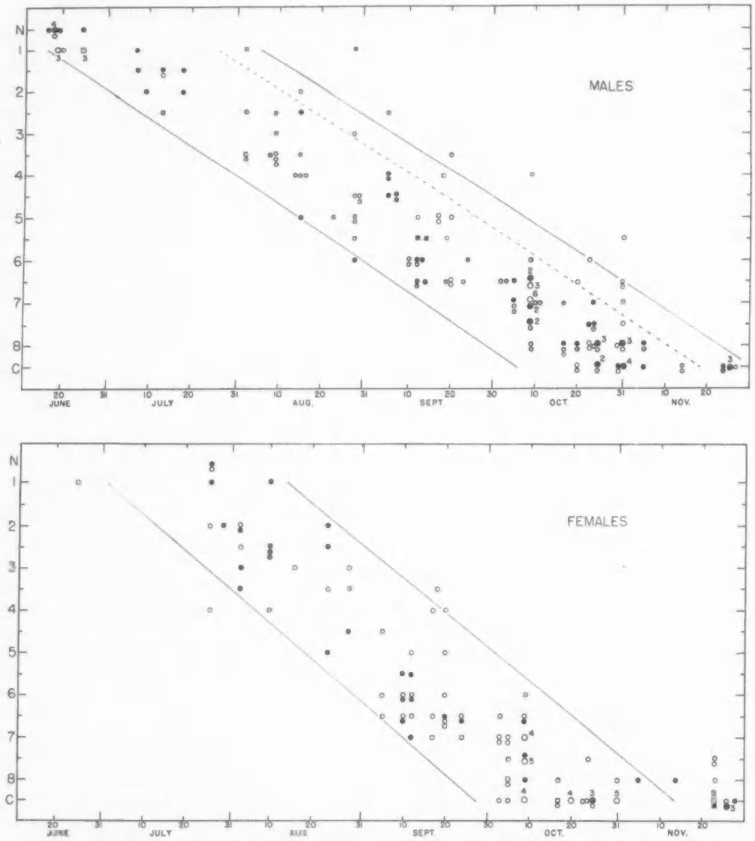

Fig. 4. Timing of molt in adult and first-year birds. Dots indicate adults, circles first-year individuals, large symbols represent two or more birds. N = no molt evident, C = molt completed, numbers from 1 to 8 refer to stages of molt. Dotted line shows separation of first-year males assigned to group A (early molting) and group B (late molting). See text for further explanation.

ing juveniles were taken on June 19 and one on June 20; one other juvenile collected on June 18 was not yet in molt. Seven adults taken in the period June 17–25 had not commenced to molt, and the first evidence of molt in adults was not seen until July 7; however, the individual taken on the latter date probably started molting about July 1. Although juveniles may begin molting slightly earlier than adults, they do not finish any earlier on the average.

It would appear that there are two fairly distinct periods of molt initiation in juvenal males. The great majority (group A in table 2) begin molting between June 19 and July 17, approximately the same time adult males are molting. The average date of inception in this group was June 29, which is about 11 days earlier than the average

Table 2

Comparison of Fall Molt in *Cassidix mexicanus*

	Males		Females	
	Postnuptial	Postjuvenal	Postnuptial	Postjuvenal
Start of molt	June 17-July 24	[1]June 19-July 17 [2]July 28-Aug. 8	July 3-Aug. 10	July 2-Aug. 10
End of molt	Sept. 28-Nov. 8	Oct. 6-Nov. 28	Sept. 26-Nov. 10	Sept. 24-Nov. 16
Period of molt in the individual	105–110 days		80–90 days	
Average date of inception	July 9	[1]June 29 [2]August 3	July 20	July 20
Latest date for specimen not yet in molt	June 25	June 19	July 26	July 26
Earliest date for specimen with completed molt	October 17	October 9	October 3	October 9

[1] Group A } see figure 4.
[2] Group B }

date for adults. Average date of inception for birds classed in group B was August 3. Birds of group B may be late-hatched individuals, perhaps products of second nestings.

Of special interest are those few juveniles whose molt progress is exceptionally far behind that of the main group of birds of their age class. The most notable of these, shown in figure 4, are: August 2, 1956, stage 1; August 28, 1956, stage 1; October 9, 1957, stage 4; and October 31, 1957, stage 5½. These birds were well below average in weight for the month in which each was taken. The bird in stage 5½ taken on October 31 weighed only 173 grams, 13 grams less than the next lightest first-year bird collected in October (table 10). In the field, it was apparent that this individual was in poor physical condition; its flight was weak and it was unable to keep up with the flock with which it was traveling. Molt was proceeding in the wing and tail and, to some extent, on the head, but molt of the sternal region apparently had stopped, despite the fact that a large medial area of juvenal feathers remained. That postjuvenal molt may in rare instances be suspended well short of completion is also demonstrated by a first-year bird collected on November 25, 1956. In this bird, there was no evidence of molt in progress. It had, however, failed to replace not only the juvenal under greater primary and secondary coverts and some tertiaries, as is usual in first-year birds, but also secondaries 3–6, rectrices 1–1, and many feathers in the interramal, loral, superciliary, ocular, and malar regions. Unlike the other abnormal individual collected on October 31, the bird was in excellent physical condition and weighed 213 grams; it was, in fact, the heaviest of five first-year birds collected in November.

Molt in females.—Molt in females requires 85 to 90 days, or about 15 days less than in males. As in the male, juvenal females, as a group, are more variable in timing than adult females, but over 90 per cent of juvenal females fall within limits determined by the span of molting adult females, and average dates of inception of postjuvenal and postnuptial molts are the same, July 20.

There are no records of suspension of postjuvenal molt in females comparable to that occasionally found in males, but in rare cases juvenal females fail to molt one juvenal primary or the central pair of rectrices.

Retained juvenal feathers in first-year birds.—Unlike the situation reported in *Aphelocoma* by Pitelka (1945), the postjuvenal molt in *Cassidix* is not invariably incomplete. In a sample of 26 males and 42 females taken from November to January and judged as first-year primarily on the basis of skull ossification, it was determined that approximately 8 per cent of juvenal males and 12 per cent of juvenal females had a complete postjuvenal molt. Percentages of first-year specimens of the two sexes that retained juvenal feathers and mean numbers of juvenal under greater primary coverts

Table 3

Retention of Juvenal Feathers by *Cassidix mexicanus* in First Year

Sex	Number	Per cent retaining some or all under greater primary coverts	Mean number of under greater primary coverts retained[1]
Male	77	90	4.3
Female	55	84	4.0
		Per cent retaining some or all under greater secondary coverts	Per cent retaining some tertiaries
Male	77	65	78
Female	55	74	85

[1] Individuals retaining no under greater primary coverts included in calculations; excluding these, mean number of primary coverts retained is 4.7 in both sexes.

retained are presented in table 3. It will be noted that a greater percentage of birds (90 per cent of males, 84 per cent of females) retain under greater primary coverts than retain either under greater secondary coverts or tertiaries.

Retained juvenal feathers are easily distinguished from new feathers, especially when replacement in a row of coverts or tertiaries is incomplete and adjacent old (juvenal) and new feathers can readily be compared. Compared to new feathers, juvenal feathers are browner (less blackish), slightly smaller, and have margins which are more frayed. These distinctions are normally apparent up until the time of the first postnuptial molt (second fall molt) and, thus, are of great value in age determination. Retained under greater primary coverts and tertiaries may be seen and sometimes counted in dry study skins, but it is difficult to examine the under greater secondary coverts without damaging the specimen by opening the wings. The present counts were made on freshly-killed, unskinned birds.

With rare exception, in cases in which partial replacement of the under greater primary coverts occurs, it is the proximal coverts that are retained. Thus, for example, covert series 1–2; 1–5; and so on are usually retained in these cases, but occasionally different series may be retained; for example, 1, 3–4, 6–7; 2–4; 1–2, 4–7; and so on. Those individuals that molt all under greater primary coverts invariably replace all under greater secondary coverts as well, and, in general, those retaining only one to three under greater primary coverts also tend strongly to replace all under greater secondary coverts. Usually it is the distal under greater secondary coverts that are retained when molt of this series is incomplete; thus, covert series 1–2; 1–6; and so forth are commonly retained, but there is a range of variation comparable to that in the under greater primary coverts.

From one to six tertiaries may be retained; these are the medial ones and are hidden by new distal and proximal tertiaries and by the new feathers of the posterior part of the humeral tract proper.

Asymmetry of replacement of coverts or tertiaries in the two wings occurs in not more than 5 per cent of specimens examined.

As mentioned previously, retention of juvenal feathers other than under greater wing coverts and tertiaries is rare. In the course of this study, one bird (male, December 19, 1956) was collected which had failed to replace rectrix 1 on one side. One male (March 14, 1957) had retained three long coverts of the leading edge of the patagial membrane; another (October 23, 1957) retained about six of these as well as under lesser secondary coverts 1–6. An abnormal adult male which had retained under greater primary covert number 7 in one wing was taken on December 19, 1956.

Since the foregoing was written, evidence has been obtained which strongly suggests that the number of juvenal birds having abnormal postjuvenal molt was greater in 1958 than in 1957. Two of six first-year males and one of three first-year females collected on February 20 and 23, 1958, showed plumage abnormalities. One male had retained juvenal primaries 1 and 2 and their upper greater coverts, secondaries 1 to 6, and about 90 per cent of the under middle primary and secondary coverts, in addition to all under greater coverts and some tertiaries. The plumage of this bird was very dull in color and the abdomen was streaked with brown. Another male had retained juvenal primaries 1 to 4 and their upper greater coverts and secondaries 1 to 6; the under middle coverts were new and plumage color was normal, however. Both birds and four normal-plumaged first-year males taken on February 20 and 23 were in early prenuptial molt. Their weights (180 and 290 grams) were normal (table 10). The abnormal first-year female had retained secondaries 2 to 6 in the right wing and 1 to 6 in the left, along with several under middle wing coverts. The weight of this bird (125 grams) was well above average. In color, the specimen was rather gray ventrally, but it was not abnormally so.

The apparent higher percentage of young birds retaining unusual types and numbers of juvenal feathers in the fall molt of 1957 probably is related to the fact that some second broods were raised in the summer of 1957 whereas none was attempted in the summer of 1956. Birds which fledged from late nestings would be relatively immature at the time of the postjuvenal molt and might on this account fail to replace some juvenal primaries, secondaries, and other feathers that are normally lost early in the molt. Evidence that the above mentioned abnormally-plumaged birds are somewhat younger than others collected in February is provided by the unusually large size of unpillared areas in their skulls. The two males had unossified patches measuring 8 and 10 mm. in diameter, whereas, as noted elsewhere, in February this diameter is normally only about 4 mm.

Prenuptial molt.—First-year males, but apparently not adult males or adult and first-year females, have a partial prenuptial molt in March and early April. This molt is sporadic and proceeds slowly, involving only a few feathers at a time. Molt centers in the head region and most frequently involves replacement of feathers of the interramal, auricular, superciliary, ocular, malar, and submalar regions of the capital tract. Often there also is some molt in the frontal, coronal, occipital, and loral regions; and in some birds there is scattered replacement in the cervical region ventrally and in the sternal and axillary regions. Less frequently some feathers of the cervical region dorsally and the interscapular region are replaced, and rarely a few feathers in the pelvic region are molted. Replacement in the auricular, superciliary, and malar regions may be complete, although generally it is not; but molt in other regions is rarely if ever complete.

Birds are highly variable individually with respect to extent of the prenuptial molt. Some individuals replace not more than a dozen feathers, while others may molt the majority of feathers of the head and anterior cervical region.

First evidence of prenuptial molt in 1957 was recorded on March 8, when a specimen was collected which showed molt in the interramal, superciliary, ocular, and auricular regions. A male, taken on March 25, had finished molting, as had another collected on April 2. Eight other males, taken between March 19 and 27, and a male collected on April 8 were molting. Six birds taken after the 15th of April had finished molting. In 1958, prenuptial molt was recorded as early as February 20, as noted elsewhere.

New feathers acquired in the prenuptial molt approach and sometimes equal those of adults in intensity of purple color and in glossiness. The effect of the prenuptial molt is to intensify the coloration of the head and anterior part of the neck, particularly the region surrounding the eye. The fact that first-year males renew feathers of the head and neck is probably adaptively related to the circumstance that these regions are prominently displayed in sexual and agonistic behavior occurring during the breeding season. By the time the prenuptial molt is finished the iris has reached full adult color. The bright yellow iris contrasts sharply with the dark glossy purple of the head and is conspicuous in sexual display.

McIlhenny (1937) made no mention of a prenuptial molt in *C. m. major*, but Lowery (1955:465) noted its occurrence in that race. A partial prenuptial molt, "chiefly confined to the neck but also affecting the head and breast," occurs in first-year male Red-eyed Cowbirds, *Tangavius aeneus* (Friedmann, 1929:337). Adult males of *T. a. aeneus* have "an irregular but always small amount of molt on the anterior parts of the body" (Friedmann, *op. cit.*:338). No prenuptial molt is reported in *Molothrus ater*.

Timing of molt.—Molt in males began at the time testes were regressing from breeding condition (Selander and Hauser, MS), but on the basis of our data it seems unlikely that there is a direct causal relationship between either this gonadal change or the accompanying supression of sexual behavior and inception of the fall molt. Similar findings are reported for the Rook (*Corvus frugilegus*) by Marshall and Coombs (1957), and Mewaldt (1958) has recently shown that molt usually begins in Clark's Nutcracker (*Nucifraga columbiana*) while the gonads are still in breeding condition. In *Cassidix*, this view is supported by the fact that juvenal birds whose gonads had not experienced cyclic development to breeding condition and regression molted very nearly in the same period as did adults. Moreover, even in older birds there was no precise relation between regression and molt inception. Although testes regressed about one month earlier in first-year males than in adults, the difference in timing of molt inception was at best 12 days. In the Redwing (*Agelaius phoeniceus*), Wright and Wright (1944:55) reported that "even though the year-old's testes regressed sooner than those of the adults . . . it does not appear that the molt starts any earlier than in the early molting adults." Lack of any mutually exclusive relationship between testicular activity and molt in *Cassidix* is indicated by the fact that fall molt is still in progress when autumnal recrudescence of testes occurs in October and by the fact that the prenuptial molt of first-year males coincides with the period of maximum rate of enlargement of the testes in March.

In *Agelaius*, Wright and Wright (*loc. cit.*) found a significant correlation in adult males between degree of advancement of the postnuptial molt and size of the regressing testes, evidence which suggests that "the physiological factors which bring about the regression of the testes may also bring about the molt . . . ." Possibly thyroid activity is involved in timing of molt and regression of testes, as pointed out to me by John Davis. In the House Sparrow (*Passer domesticus*), Davis and Davis (1954:342) found that the thyroids are active prior to molt, and they have presented evidence suggesting that "it is possible that the thyrotropic and gonadotropic functions of the pituitary are antagonistic." That thyroid activity influences molt in chickens is well known (Sturkie, 1954:

363). Assuming that pre-molt thyroid activity also depresses testicular development, it may be possible to account for the fact that the testes of some juvenal birds, which are slightly enlarged in June and the first part of July, "regress" to a completely inactive condition by August (Selander and Hauser, MS).

The delay of the postnuptial and postjuvenal molts until the young are well grown and fledged, seen in the Boat-tailed Grackle and in many other species of temperate birds, is probably an adaptation permitting maximum use of available food by the rapidly growing nestlings and reproductively active adult and first-year birds in the breeding season and by the molting population in the late summer and early fall. Various aspects of the problem of timing of events of the avian annual cycle in relation to food supplies are discussed by Lack (1954) and Pitelka (1958). Little can be added from the present study because quantitative data on food abundance are not available, except to note that both in 1956 and 1957 fall molt coincided with population highs of adult field crickets (*Gryllus* sp.) in the Austin region.

First-year and adult plumages.—The first-year and adult plumages of females are closely similar, but there are some average differences other than the usual presence of retained juvenal under wing coverts and tertiaries in first-year birds. Most of these have been noted by Phillips (1950:78). First-year females are often paler ventrally and on the sides of the head; the buff or cinnamon brown ventral color is grayer with less admixture of brown. As a result, the buff superciliary stripe is lighter and more conspicuous and the dark submalar stripe is more apparent. Ventral coloration is highly variable in both age groups, but it is especially so in first-year females, in which it ranges from dusky brown with dark shaft streaks to a rich cinnamon brown. Overlap between the age groups is too great for the character to be of much practical value in age determination, but by and large darker females are adult and paler ones are first-year. In figure 3, one of the paler first-year female specimens available is shown with the darkest adult collected. In worn plumage, the brown color of the under parts may remain more conspicuous on the breast of adult than first-year birds.

Dorsally, feathers of first-year females sometimes have narrow brown margins which are generally lacking in adults. The dorsal feathers are somewhat less iridescent than those of adults, but there is much overlap in this regard.

The rectrices, remiges, and upper wing coverts of first-year females average slightly browner and less iridescent. Also, they tend to wear and fade with greater rapidity and may be frayed and light brown in color by late spring, when those of adult females are only slightly faded. These feathers in first-year females are narrower than those of adults, and the rectrices are more rounded or less truncate terminally. This again is an average difference: mean maximum width of the outer rectrix in 10 adult females was 22.8 mm. (range, 21.0–23.6), and in 10 first-year females, 21.1 mm. (19.0–23.1).

Most of the differences mentioned above become increasingly less apparent as a result of plumage wear and fading with the advancing season. Even so, with experience it should be possible to correctly determine the age of between 65 and 75 per cent of female museum specimens using these characters alone.

Differences in first-year and adult male plumages require little further comment. The adult plumage is everywhere more iridescent, and the metallic colors are more bluish or purplish, less greenish. Following prenuptial molt, the color and iridescence of the head and neck of some first-year males may approach that of adults, but the other areas of the body which are conspicuously browner and duller, particularly the posterior under parts, makes identification a relatively simple matter.

As in females, the rectrices, remiges, and wing coverts of first-year males are duller,

paler, and narrower than in adults. The degree of overlap between males of different age groups is much less than in females. The rectrices of adult males are markedly broader and less rounded terminally than in first-year males, but, as mentioned previously, there is some overlap in this character.

Adult males are remarkably alike in color, whereas first-year males are highly variable both in color and degree of iridescence. Some "retarded" first-year males have coloration more or less intermediate between normal first-year color and that of the juvenal plumage. This is particularly evident on the abdomen, where markings similar to those of the juvenal plumage are frequently present. Viewed under good lighting conditions, even the most "advanced" first-year males are less iridescent than adults, so that 100 per cent separation of specimens is possible on the basis of color alone.

Albinism.—In view of the high frequency of albinism in some icterids (Nero, 1954), this character is surprisingly rare in *Cassidix* (Sprunt, 1958:37). Only random, partial albinism, involving absence of pigment in one or a few wing coverts, contour feathers of the body, or rectrices was recorded. This occurred in about three per cent of the specimens examined.

IRIS COLOR

Males.—Without exception, the irides of adult males are bright, intense yellow. In juveniles, the irides are dull brown; this changes over a period of several months to the adult color (table 4). The transition involves a gradual loss of brown pigment and a progressive intensification of yellow pigment. In May (1 record) the juvenal iris was

Table 4

Iris Color in First-year Birds

	Males		Females	
Month	Subadult color	Adult color	Subadult color	Adult color
August-Sept.	26	....	23	....
October	33	....	47	....
November	5	....	13	....
December	3	2	2	1
January	3	3	1	1
February	10	10	9	2
March	3	9	2	2
April	....	8	....	1
May-July	....	13	....	1
Totals	83	45	97	8

"dark brown;" in June (8 records) it was "dull yellowish brown;" and in July (2 records) it was "pale brownish yellow." There was a wide range of variation in iris color in first-year birds in August, September, and October. The average condition was "pale yellow," with extremes described as "pale whitish or grayish yellow" and "flat yellow of moderate intensity." Intensity of yellow continued to increase through November, and by December some individuals had irides that were adult in color. By January and February, 50 per cent of first-year males had adult iris color and in several other individuals the color was only slightly less intense than in adults; by March, 75 per cent were adult in color. None of 8 first-year males, taken in April, or 13 specimens, collected in May, June, and July, had subadult color.

Iris color is variable geographically in *Cassidix mexicanus* and should be carefully investigated. In adult male *C. m. major* in Louisiana, according to Lowery (1938:6),

"the region of the pupil is brown, but the periphery of the iris is yellow." In adult females of *C. m. major*, the iris is brown. According to McIlhenny (1937:275), while adult males are engaged in "battle or courtship" the iris changes from hazel to brilliant gold, as the pupil contracts. However, in *C. m. prosopidicola* there apparently is no color change during display. The pupil may be contracted, however, and the yellow iris expanded and rendered very conspicuous.

Females.—In adult females, the yellow of the iris is less intense or paler than in adult males, resembling that of first-year males taken in late November. Color changes from the juvenal brown to the adult yellow are similar to those described for males, and rates of development of adult color (table 4) would seem to be about equal in the two sexes, or, perhaps, slightly slower in females.

SKULL OSSIFICATION

Males.—In the vast majority of males, the cranium shows some unpillared or unossified areas throughout the first year of life. Occasionally, however, the skull may ossify completely as early as February, as shown in table 5. There is considerable indi-

Table 5

Cranial Condition in First-year Birds

Month	Males		Females	
	Incompletely ossified	Completely ossified	Incompletely ossified	Completely ossified
August-October	91	....	65	....
November	5	....	13	....
December	5	....	3	....
January	6	....	2	....
February	16	1	11	....
March	10	2	5	1
April	6	2	1	....
May	6	....	....	....
June	3	....	1	....
July	4	....	....	....
Totals	152	5	101	1

vidual variation in size of unpillared areas in birds taken in any one month, reflecting age differences and individual variation in speed of ossification. Thus, one individual taken in October had smaller unpillared areas than were present in some individuals taken in May. By February, the diameter of unpillared patches (generally two on either side of the cranium) normally is reduced to about 4 mm. These patches may be partially pillared and are likely to be overlooked if the cranium is not carefully examined in transmitted light. In June and July, the patches have diameters of 1 or 2 mm.

In 159 adult males examined, only four (2.5 per cent) did not have the cranium completely ossified. Presumably these birds were adults which had undergone only one postnuptial molt. The first of these was taken on August 28, 1956; it had a single unpillared area about 4 mm. in diameter on either side of the cranium. In December, 1956, three adult males having very small unpillared patches were collected. In the latter birds, it is probable that ossification was suspended and would not have gone to completion. The birds were normal adults in all other characters.

Females.—Data are less complete for females, but they indicate a rate of ossification comparable to that of males. Complete ossification in a first-year female was first

recorded on March 8, 1957. In 54 adult females examined, only two (3.7 per cent), a bird taken on August 23, 1956, and one collected on September 24, 1956, had an incompletely ossified cranium.

Pattern and variability in rate of ossification are similar to those of males.

SIZE VARIATION

Measurements are given in tables 6 and 7.

Sexual differences.—In the Icteridae, males are larger than females, and there is a wide range of variation in degree of sexual dimorphism in size (table 8). The trend is

Table 6

Measurements of Males

Dimension	Age group	Number	Period	Mean	Range	Standard deviation
Wing length	Adult	137	Oct.-July	184.3 ±0.4	173–200	4.7
	First-year	81	Oct.-July	174.5 ±0.5	165–188	4.2
Tail length	Adult	119	Oct.-July	203.8 ±0.9	178–232	9.6
	First-year	75	Oct.-July	178.9 ±0.8	165–200	6.8
Bill length	Adult	26	Aug.-Nov.	30.54	26.7–34.0	
		47	Dec.-March	30.83	28.0–33.2	
		38	April-May	31.95	29.0–34.8	
		20	June-July	32.47	29.8–37.0	
		131	Aug.-July	31.34±0.14	26.7–37.0	1.59
	First-year	26	Aug.-Sept.	27.36	22.4–31.9	
		15	Oct.-Nov.	28.91	26.6–30.5	
		35	Dec.-March	29.49	27.5–32.5	
		13	April-May	29.51	28.2–33.3	
		7	June-July	30.93	29.2–34.8	
		96	Aug.-July	28.93±0.19	22.4–34.8	1.82
Bill depth	Adult	132	Aug.-July	12.64±0.04	11.3–14.1	0.49
	First-year	97	Aug.-July	12.29±0.05	10.5–13.5	0.53
Bill width	Adult	132	Aug.-July	9.87±0.04	8.4–11.2	0.52
	First-year	98	Aug.-July	9.60±0.06	8.0–11.0	0.61
Tarsus	Adult	133	Aug.-July	46.38±0.14	41.8–50.0	1.66
	First-year	98	Aug.-July	45.89±0.18	41.3–50.0	1.80
Middle toe	Adult	134	Aug.-July	33.66±0.12	30.1–37.9	1.39
	First-year	97	Aug.-July	33.22±0.16	30.0–37.3	1.60

for increased dimorphism in species having polygamous or promiscuous mating relationships. The degree of sexual size difference in *Cassidix mexicanus prosopidicola* equals that of the promiscuous oropendolas *Zarhynchus* and *Gymnostinops*. *Quiscalus* is markedly less dimorphic than *Cassidix*. The average percentage difference for four dimensions falls between those of two species of *Holoquiscalus*, a "genus" which is lumped with *Quiscalus* by some authors, but which is, on the basis of structure (Ridgway, 1902:222-224) and behavior (Selander, MS), actually as close to *Cassidix*. It is significant that the degree of size difference in *Cassidix nicaraguensis* is intermediate between that of *Holoquiscalus* and *Cassidix mexicanus*, because *C. nicaraguensis* is in certain other respects intermediate between the more northern species of *Cassidix* and *Holoquiscalus* (Ridgway, 1902). It is obvious that the current classification of the typical grackles in

three separate genera does not adequately reflect the relationships between them and is in need of revision.

Age differences.—The wing averages 5.3 per cent longer in adult than in first-year males; in females the difference is only 2.2 per cent. Age difference in tail length is more marked; 12.2 per cent in males and 8.4 per cent in females.

Wing-to-tail ratios, expressed as wing length as a percentage of tail length, are shown in table 9. The ratio has some value as an age criterion. On the basis of this ratio alone it is possible to distinguish approximately 50 per cent of first-year females from all adult females; about 40 per cent of first-year males are distinguishable from all adult male specimens.

In adult males, there is an increase in bill length in the summer (April through July), amounting to about 1.5 mm. as compared to specimens taken between October and

Table 7

Measurements of Females

Dimension	Age group	Number	Period	Mean	Range	Standard deviation
Wing length	Adult	26	Oct.-June	143.4 ±0.2	135–150	3.5
	First-year	62	Oct.-June	140.2 ±0.1	135–147	2.7
Tail length	Adult	25	Oct.-June	144.5 ±1.2	132–154	5.9
	First-year	51	Oct.-June	132.4 ±0.7	122–145	5.2
Bill length	Adult	32	Aug.-March	24.22±0.18	22.2–25.9	0.99
	First-year	11	Aug.-Sept.	22.54	21.3–23.7	
		11	Oct.-Nov.	23.04	21.6–23.8	
		16	Dec.-March	23.66	21.4–25.9	
		1	June	24.1		
		38	Aug.-March	23.15±0.17	21.3–25.9	1.07
Bill depth	Adult	31	Aug.-March	10.38±0.06	9.9–12.3	0.32
	First-year	38	Aug.-March	10.18±0.06	9.6–11.3	0.12
Bill width	Adult	32	Aug.-March	7.99±0.12	7.1–8.9	0.46
	First-year	38	Aug.-March	7.97±0.09	7.2–9.4	0.54
Tarsus	Adult	31	Aug.-March	38.50±0.24	35.7–40.8	1.31
	First-year	38	Aug.-March	38.11±0.25	35.1–40.5	1.56
Middle toe	Adult	31	Aug.-March	28.05±0.22	25.8–30.1	1.20
	First-year	38	Aug.-March	27.75±0.20	25.4–30.4	1.22

March (table 6). Presumably a comparable increase occurs also in females, but insufficient data are available for the summer months (table 7). This increase is probably related to a seasonal change in diet; grackles eat greater amounts of insects in summer than in winter (Beal, 1900). Davis (1954:148) has demonstrated similar summer increase in bill length in the Brewer Blackbird (*Euphagus cyanocephalus*) and some other passerines. He suggested that the most likely cause "is the reduced amount of wear put on the constantly growing bill tip by a diet rich in insects." It may be noted the degree of seasonal variation in *Cassidix* is great enough to warrant consideration in studies of geographic variation in bill length.

In first-year birds, there is a gradual increase in bill length through the first year of life, but on the average the bill is nearly fully grown by December. Period for period bill length averages slightly less in first-year birds than in adults.

Seasonal variation in body weight.—Data on body weight are presented in table 10 and figure 5. In all months, first-year birds average less in weight than adults.

In August, average weight of adult males was less than at any other time of the year.

Table 8

Sexual Dimorphism in Size and Mating Relationship in Various Icterids
(Percentage Difference Between Sexes)

Species and race	Wing	Tail	Bill length	Tarsus	Mean	Mating relationship of species
Cassidix mexicanus prosopidicola	22.2	29.1	20.7	17.0	22.3	Promiscuous[1]
C. m. major	22.1	26.8	18.8	17.5	21.3	Promiscuous[2]
C. m. mexicanus	20.2	27.4	18.7	15.7	20.5	Promiscuous[3]
Cassidix palustris	22.4	27.2	14.0	17.3	20.2	Unknown; promiscuous?
C. nicaraguensis	18.0	25.9	14.9	14.7	18.4	Unknown; promiscuous?
Holoquiscalus niger niger	15.7	14.8	13.4	10.0	13.5	Monogamous and probably polygynous[4]
H. lugubris guadeloupensis	12.5	11.9	10.9	8.6	11.0	Unknown
Quiscalus quiscula quiscula	11.1	17.4	13.6	6.3	12.1	Monogamous (and polygamous?)[4]
Euphagus cyanocephalus	8.5	10.0	11.1	5.6	8.8	Mainly monogamous; polygyny common[5]
Euphagus carolinus	5.7	9.3	2.7	0.0	4.4	Monogamous
Dives dives	11.2	8.5	8.5	4.6	8.2	Monogamous[3]
Scaphidura oryzivora	21.7	23.0	12.6	8.6	16.5	Probably promiscuous[3]
Tangavius aeneus aeneus	11.5	7.7	10.8	9.4	9.9	Unknown
Molothrus ater ater	8.5	11.2	11.1	4.9	8.9	Monogamous?[6]
Agelaius phoeniceus phoeniceus	18.2	19.1	18.2	14.2	17.4	Mainly polygynous; occasionally monogamous[6]
Icterus spurius	6.4	3.8	3.7	0.0	3.5	Monogamous
Icterus galbula	8.4	9.6	4.4	3.4	6.4	Monogamous
Amblycercus holosericeus	9.6	7.1	3.2	7.0	6.7	Monogamous[3]
Zarhynchus wagleri wagleri	28.6	22.8	24.7	17.2	23.3	Promiscuous[7]
Gymnostinops montezuma	24.8	22.8	23.5	20.0	22.8	Promiscuous[8]

[1] Selander and Hauser (MS); measurements for *Cassidix mexicanus* from present study and Lowery (1938); other measurements from Ridgway (1902).
[2] McIlhenny (1937).
[3] Skutch (1954).
[4] Selander (MS).
[5] Williams (1952).
[6] Nero (1956).
[7] Chapman (1928).
[8] Bent (1958); Friedmann (1929).

This is due in part to the fact that at least one "new" adult in first postnuptial molt is included in the sample. This bird weighed only 175 grams and apparently was not quite fully grown, although it was at least 13 months old. First-year males averaged 12 grams less than adults in August, at which time some first-year birds were still in a phase of rapid growth.

In September, there was an increase in average weight in both age groups of males. Food was plentiful and the birds accumulated fat as they were molting. The apparent slight drop in weight in October may be due to sampling error; but because it is shown in both age groups, there is reason to suspect that it is real and reflects the strain of physiological demands imposed by the molt, which was drawing to a close, and by autumnal sexual activity, which reached a maximum in mid-October (Selander and Hauser, MS). Food was less readily available in October than in September.

Weight of males remained relatively constant from November through March, but the data suggest a gradual loss in both age groups through December, January, and February. In this period, food was relatively scarce, temperatures were low, and rain was frequent. Long flights were made in search of foraging grounds.

The initiation of testicular development in February was not accompanied by a

Table 9

Wing to Tail Ratios in *Cassidix mexicanus*

(Wing Length as Percentage of Tail Length)

Age and sex	Number	Mean	Range	Per cent in which wing length equals or exceeds tail length
Adult male	118	90	80–98	0.0
First-year male	74	98	91–103	28.0
Adult female	24	101	95–107	58.3
First-year female	50	94	89–101	8.0

significant change in body weight. However, in March weight of adults apparently was increasing and it reached a maximum in April, coincident with the attainment of maximum testis volume. Body weight and testis volume of first-year males peaked a month later in May. In both adult and first-year males, testis regression was accompanied by a significant decrease in body weight. Regression occurred approximately one month earlier in first-year males (Selander and Hauser, MS).

In February and March, weight of adult females remained near the December-January level, but that of first-year birds fell off slightly.

Almost no data are available for females in the breeding season. A first-year female taken on June 25 weighed 110 grams.

Table 10

Monthly Body Weights, 1956–1957

	Males				Females			
Age group and month	Number	Mean	Range	Standard deviation	Number	Mean	Range	Standard deviation
First-year								
August	25	184.9±2.4	159–203	12.1	6	113.7	106–120	
September	16	196.3±3.7	172–230	14.7	18	114.6±1.2	105–120	5.0
October	42	191.4±1.5	171–212	9.6	51	113.9±1.0	99–138	7.1
November	5	203.8	189–213		13	117.5±2.0	102–129	7.2
December	5	199.8	192–208		5	119.0	113–123	
January	5	198.8	192–212					
February	13	193.2±3.4	169–210	12.1	12	114.0±2.4	99–126	8.4
March	12	189.8±2.6	175–209	9.0				
April	7	194.0	185–209					
May	6	203.5	191–217					
June	3	183.0	173–188					
July	4	187.5	177–194					
Adult								
August	4	197.0	175–209		15	116.4±2.3	102–131	8.8
September	9	211.3	195–223		10	120.7±1.3	114–129	4.2
October	23	205.9±2.6	187–240	12.7	5	115.8	110–124	
November	7	213.3	200–236		6	119.8	105–132	
December	12	212.7±4.8	185–237	16.9	6	123.2	117–129	
January	16	208.5±3.5	181–235	14.0				
February	11	206.0±3.3	187–217	10.9	6	121.6	117–126	
March	9	211.9	197–243					
April	17	227.1±3.1	205–250	12.8				
May	21	219.7±2.8	199–244	12.9				
June	17	225.6±3.5	204–253	14.6				
July	3	202.0	195–207					

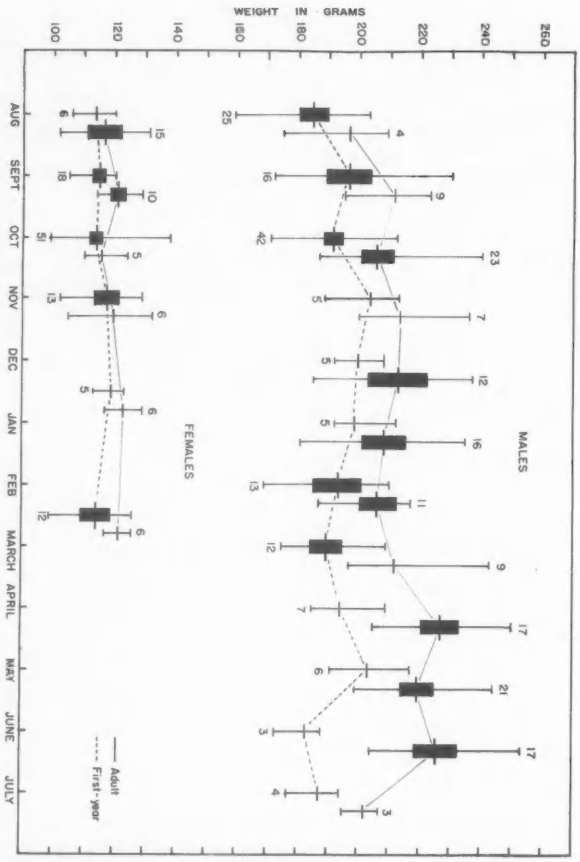

Fig. 5. Seasonal variation in body weight in different sex and age groups of *Cassidix m. prosopidicola*, showing sample size, mean, twice standard error of mean on either side of mean, and range.

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SUMMARY

Age determination and molts and plumages in *Cassidix mexicanus* have been studied, based on 493 specimens of *C. m. prosopidicola* from the Austin region, Travis County,

Texas. Using a combination of criteria it was possible to determine the age of all specimens examined.

The pterylography of the under wing and the sequence of molts and plumages are described.

The postjuvenal molt in *Cassidix mexicanus* and in at least some related genera of blackbirds is usually incomplete, some or all juvenal under greater primary and secondary coverts and some juvenal tertiaries being retained. In *Cassidix mexicanus* the postjuvenal molt is complete in eight per cent of the males and 12 per cent of the females.

The period of the postjuvenal and postnuptial molts in males lasts from 105 to 110 days; in females the molt period is 80 to 90 days. Juveniles undergoing postjuvenal molt and males undergoing first postnuptial molt may begin molting a few days earlier than older birds. Postjuvenal molt is characterized by irregularities and great individual variation in timing, especially in males. In rare cases, the postjuvenal molt is suspended well short of completion. The proportion of juveniles having abnormal postjuvenal molt was apparently greater in 1957 than in 1956.

There is no evidence of a direct relationship between testis regression and the inception of the fall molt.

In the vast majority of birds, the cranium remains incompletely ossified or pillared throughout the first year of life, but occasionally it may be completely ossified by February. In some individuals, ossification is suspended. Iris color changes from brown in juveniles to bright yellow over a period of months. Some individuals have adult iris color by December; in others the color may be subadult as late as March.

In the Boat-tailed Grackle, sexual dimorphism in size approaches an extreme among icterids illustrated also by the oropendolas *Zarhynchus* and *Gymnostinops*, that is, among members of the family in which mating is polygamous or promiscuous. In the Icteridae, there is a trend of increase in size dimorphism between sexes in those species showing such mating relationships.

In adult males, there is an increase in bill length in the summer, a phenomenon probably related to seasonal changes in diet. In first-year birds, bill length gradually increases through the first year of life.

Weight of adult males began increasing in March, a month after testicular development was initiated, and it reached a maximum coincident with attainment of full testis volume in April. Body weight and testis volume peaked a month later in first-year males. In both age groups, testis regression was accompanied by a loss of weight.

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NESTING BEHAVIOR AND FOOD HABITS OF GOSHAWKS IN THE SIERRA NEVADA OF CALIFORNIA

By JAY H. SCHNELL

This study deals with nesting and food habits of Goshawks (*Accipiter gentilis*) with special reference to the adaptive behavioral mechanisms of large avian predators. The scope of the paper has been limited because of delay in finding a suitable nest for observation. By June 16, 1956, when the nest was located, the eggs had hatched and the nestlings were about a week old. Unfortunately, only limited information was obtained after the young had left the nest. This was due in part to the difficulty of following the fledglings and in part to lack of time for continuance of the study. Thus few data were obtained on territory size and behavior outside the nest area.

The literature contains little information on behavior or food habits of the Goshawk in North America. The accounts that have been published, although lacking in detail, have been helpful in understanding the various phases of the nesting cycle that were not followed in the present investigation. Zirrer (1947) presents observations on courtship and nest-building activities in northern Michigan. Siewert (1933) gathered valuable information on incubation behavior. Dixon and Dixon (1938), Gromme (1935), and Sutton (1925) also present informative observations on nesting activities. Sulkava (1956) studied seasonal variations in the diets of Goshawks in Finland.

My efforts were focused on continuous observation of a pair of nesting Goshawks at Donner Lake, Nevada County, California. A blind, erected approximately 50 feet south of and five feet above the level of the nest, afforded an unobstructed view of activities about the nest. The identification of prey was aided by use of a 20X telescope. A consistent schedule of observations was followed in the blind. Continual watch was maintained from 5:00 a.m. to 8:45 p.m. This was followed on alternate days for a period of five weeks or a total of 19 observation days. On days not spent in the blind, pellets were collected and plucking posts were examined for prey remains. The study involved a total of 408 hours, 294 spent in the blind and 114 hours in field activities. Field excursions in some instances entailed the collection of prey species by the use of snap traps. Specimens thus obtained were used throughout the study period for reference in identification during observations at the blind. Weight and feather measurements of the developing young were taken at approximately 11:00 p.m. every four days. Individual nestlings could be identified while in the nest by marks of colored lacquer which were applied to the head region.

A new technique was tried for one observation day toward the end of the study. This consisted of removal of the food item immediately after delivery to the nest; the prey was identified, weighed, and then returned. Such a procedure could not be continued because disturbance of normal activity was too great.

Daily activity charts were constructed for the 19 days of observation. These were constantly used both in the organization of material and when a particular behavioral event needed special interpretation. Each delivery of food to the nest was individually entered on a mimeographed form and its type classified. Prey identification, prey condition, and amount of prey consumed, together with other significant events associated with delivery, were entered on this form. Pellets collected below the nest were analyzed in several instances where prey identifications from the blind were uncertain.

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within the park boundaries where the nest was located. Thanks are also due the Max C. Fleischmann Foundation of Nevada which generously contributed to the facilities at the Sagehen Creek Project of the University of California where I was permitted to use various research instruments. R. C. Banks donated much time in assisting with the construction of the blind. Richard Gard, Kenneth May, Don Defoe, and Bill Nisbet assisted with measurement of the young. William Shinners of Reno, Nevada, spent much time with me attempting to locate nest sites and relating his field experiences with Goshawks. I am indebted to Alden H. Miller for assistance and guidance through the entire project.

THE NEST AREA

Donner Lake is situated in a basin which drains to the east. Its shores are fairly precipitous banks and there is little shallow water. The nest under observation (fig. 1) was located on a slightly elevated bench which extends on a level plane southward from the east end of the lake for perhaps three quarters of a mile. Two old Goshawk nests were found in the immediate area, and it is probable that nesting occurred here annually over many years. Records go back 34 years, to August 9, 1923, when a streaked juvenal male, attended by its parent, was collected at this point by Alden H. Miller.

The zonal distribution of breeding Goshawks in California according to Hall and Grinnell (1919:62) and Miller (1951:534) is the Canadian Life-zone. However, the area studied was not clearly assignable to this zone. The presence of faunal and floral representatives from both Canadian and upper Transition zones indicated that it is intermediate between the two. There are published records for the western United States of nests in the Canadian Zone (Dixon and Dixon, 1938; Rowley, 1939) and the upper Transition Zone (Ingles, 1945), and there is one from the Upper Sonoran Zone (Bond, 1940). Nests are usually placed in a lodgepole pine (*Pinus contorta*), as were five nests discovered by me. However, there are records of nests in red fir, *Abies magnifica* (Grinnell and Storer, 1924:287), aspen, *Populus tremuloides* (Rowley, 1939:247), and the narrow-leaved cottonwood, *Populus angustifolia* (Bond, 1940:101). The species of tree chosen obviously depends on what is available, but conifers are preferred when present.

The study nest was located in a dense lodgepole pine forest (fig. 1) which had a canopy approximately 40 to 80 feet in height. Subcanopy layers were poorly represented or entirely absent. Pine needles covered the ground to depths of six inches. During the early phases of the nesting season, the forest floor is interspersed with impoundments of snow-melt water.

The nest proper was placed in a lodgepole pine at a height of 35 feet (fig. 1). Nests found by Rowley (1939:247) and Ingles (1945:215) were at heights of 15 and 45 feet, respectively, and represent extremes.

At the periphery of the nest area to the east, south, and west, the forest becomes less dense and the canopy somewhat discontinuous. In these areas, fallen and arched trees were used as plucking posts. These were perches where prey items, brought into the nest area by the adults, were plucked of some of the larger feathers or defurred on certain portions of the body. They were marked by prey remnants immediately below the perching structure. Not all likely perches were used for plucking purposes; height, accessibility, and sturdiness of structure appeared to be important factors influencing choice. The average distance from the nest of ten perches found in the area was 225 feet with a maximum of 425 and a minimum of 100 feet (fig. 4). It was learned that perches were not extensively utilized for plucking purposes during the nestling and early fledgling stages of the young Goshawks. This can be explained by the fact that principally nestling birds were fed to the young hawks and plucking was therefore unnecessary. It is postulated that most plucking activities occur in the course of the courtship

and incubation phases of the nesting cycle when nestling prey are not abundant. Sulkava (1956), who studied variations in Goshawk food habits during six nesting seasons, found that adult avian prey was abundant in the diet throughout the nest building and

Fig. 1. Study nest of Goshawks (*Accipiter gentilis*), located about 35 feet from the ground in a lodgepole pine (*Pinus contorta*).

incubation stages, while young birds were largely represented in the diet after the hatching of the young Goshawks. A plucking perch in the nest area is shown in figure 2.

It became evident after several days of observation that set patterns of approach and departure were adhered to by the adult Goshawks as they flew through the dense lodgepole stand. Certain flyways were evidently dictated to the birds by the limits of their structure and maneuverability. Dixon and Dixon (1938:8) state that the birds they watched seemed to be creatures of habit in that they always approached the nest from the same side and always lit on the edge of the nest in almost the same spot.

ACTIVITY PATTERNS

Before discussing some of the more specific aspects of Goshawk behavior, a general picture of nesting activities will be presented.

Daily pattern.—As the nest area becomes illuminated at approximately 5:00 a.m., Goshawk activity begins. The female, if brooding the young, becomes alert and looks keenly at the ground or surrounding area. Her head turns abruptly from one fixed posi-

tion to another between periods of concentration. Should the nestlings become active, the female is momentarily distracted. She rises slightly and allows the nestlings to move more freely. When they cease to struggle, the female settles again into the brooding position and arranges her breast feathers over the nestlings by a side-to-side rocking motion. By arching her neck slightly over her breast and lifting her body backward, the female was often observed to nudge a protruding nestling lightly with her beak. When the brooding position is regained, the female again becomes alert and watches the sur-

Fig. 2. Plucking perch of Goshawks at position 1 (see fig. 4). Photograph taken April 15, 1957.

rounding area. After perhaps 15 minutes, if no further distractions occur, she may ruffle her feathers, causing her head to lose its sleek, alert appearance, and then close one or both eyes for short periods of time.

The female was observed to continue brooding and scanning the area without changing position for periods ranging up to three hours. More frequently, she would re-orient herself on the nest at intervals or stand on the rim or branch nearby while perching, stretching, and preening activities were performed. The female was observed to remain perched for from two minutes to an hour and 35 minutes before returning to the brooding position. Before settling once more on the nest, an activity which I have termed "excavation" was often performed by the female. This seemed to be a modified nest-building action which apparently functioned to prevent food decay on the floor of the nest.

Any of the foregoing activities were discontinued if the male called in the nest area. In this event, the female would move slowly to the nest rim, step around the nestlings and, while calling, fly to the position of the male. This maneuver resulted in the transfer of prey from male to female. After such a "transfer," the female returned to feed the young and the male left the area. Usually the entire carcass was fed to the nestlings. If, in the course of the meal, they reacted slowly in taking the food from the female and if they ceased to beg vigorously, feeding was discontinued. With the partly eaten carcass grasped in one foot, the female would leave the nest and store the food somewhere in the area to be used for future feedings.

After the young had been fed and brooding or perching had been resumed for a short period, the female would often engage in sprig-collecting activities. Fresh sprigs of lodge-

pole pine were removed from the canopy up to distances of 50 feet from the nest and then dropped on the nest platform, but usually no immediate effort was made to incorporate them in the nest structure. Replenishment of pine sprigs was continued throughout most of the nestling stage of the breeding cycle (fig. 3).

In the blind at 5:00 a.m., the average temperature for 16 observation days was 40.6°F. with a minimum of 32°F. and a maximum of 50°F. At noon, temperatures rose as high as 95°F. in direct sunlight. The temperatures were usually not above 65°F. at dusk, and they dropped rapidly after the sun had set.

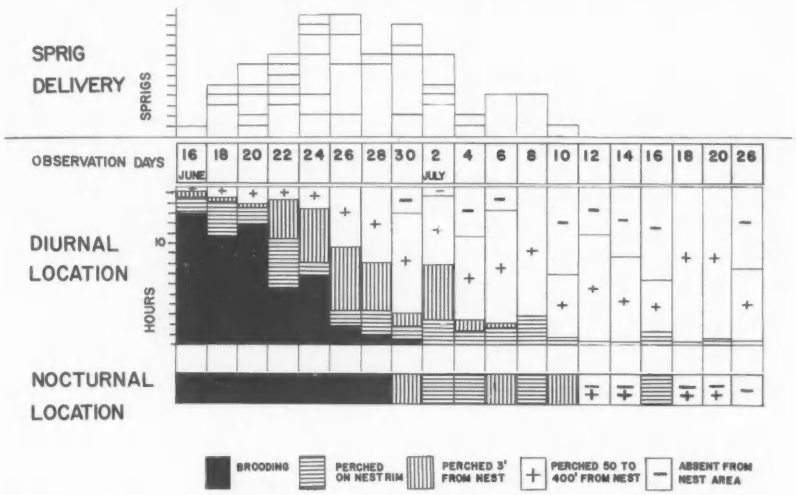

Fig. 3. Activity of female Goshawk. In Sprig Delivery histogram, the total height of each bar equals the total number of sprigs brought to the nest. The number of horizontal lines in each column equals the frequency of sprig-collecting activities for each day. The chart below (Diurnal Location) indicates the activity of the female during each day of 15½ hours of daylight. Nocturnal Location was determined by the location of the female when observations terminated at the blind at dusk.

In the morning, when the temperatures became approximately 52°F. (between 8 and 10 a.m.), insects began to swarm around the nest. These most likely were ceratopogonid flies, which are blood feeders. Insects were observed to pester the nestlings and the female incessantly. The female engaged in fly-catching activities whenever she brooded or perched near the nest. She would watch intently when a gnat or fly landed nearby and then move her head slowly forward until within striking distance. A sudden stab with the beak secured the insect. On one occasion, an insect was swallowed. Black flies (*Simulium* sp.) often crawled in and over the down of the sleeping nestlings. If the female was watching, she would move to the young and gently pick off any visible insects.

Prey species often passed through the nest area unaware of the female and the young Goshawks. The female was observed to locate immediately any movement in the area, and she would often concentrate intently on Oregon Juncos (*Junco oreganus*) moving about on the forest floor. If an animal or bird was close at hand or otherwise readily available, the female would drop from the nest rim to make the capture.

There is considerable division of labor between the male and female resulting from

the differences in their behavior. The male is almost entirely responsible for supplying the family with food, whereas the female performs a more sedentary role. Of 88 prey items brought to the nest, the male brought 75 items, or 85 per cent; the female brought 13 items, or 15 per cent. Never did the male share in actual feeding of the young. This was done entirely by the female. Several times the male was subjected to stimuli which, in the female, would have induced feeding of young, but no response was evoked in him. The male was observed several times to drop food into the nest, stand rigidly on the rim and look curiously at the begging nestlings. Dixon and Dixon (1938:11) report that the male Goshawk tried to get the nestlings to help themselves by half-heartedly picking at exposed pieces of raw meat. I have never observed the male picking at meat while on the nest. He usually left the rim several seconds after depositing the prey item.

Sprig collecting was performed entirely by the female, except in one instance when the male brought a dead twig to the nest.

Goshawk activity ceased at sunset, approximately 8:45 p.m.

Seasonal patterns.—In the present study, no observations were made during the nest building or incubation stages of the breeding cycle. Zirrer (1947) describes what appeared to be the nuptial flight of a pair of nesting Goshawks in northern Wisconsin. He observed nest-building activities in the same pair. He states that the female builds the nest alone, breaking twigs from prostrate young trees or collecting them from the ground. She takes considerable time to select each individual branch and to incorporate the twigs into the nest structure.

Siewert (1933:53) describes behavior of *Accipiter gentilis marginatus* during the incubation period (translated from the German): "On May 3, I observed from 8:15 a.m. to 4:45 p.m. The male brooded in the eight and a half hour period from 1:45 p.m. to 3:30 p.m., or one and three quarter hours. On May 10, the male brooded on the nest during a ten hour period of observation from 7:02 a.m. to 8:10 a.m. and from 1:40 p.m. to 3:40 p.m."

The activities discussed previously under "daily pattern" are subject to modification in some instances as the nesting season progresses. Such changes in the activity of the female are presented in figure 3. As may be seen, the incidence of brooding diminishes. The nestlings increase in size and activity, physically preventing the female from continuing to brood. She is still motivated, however, to stay close to the nest, as is evidenced in the increased time spent on the rim or on a nearby branch (fig. 3: barred portions of the individual columns). Eventually this motivation wanes and more and more time is spent away from the nest. At first distances of 50 to 400 feet were involved (blank portions of bars marked +), but as the season progressed, the nest area was left entirely for varying periods (blank portions of bars marked −).

The nocturnal position of the female showed similar changes (fig. 3). In the early phases of the study, the female returned to the nest to brood the young at night. On June 17, it was evident that the female was strongly motivated to return and brood the nestlings. After being flushed from the nest in the course of weighing activities at 11:00 p.m., she was present at the nest at 5:00 a.m. the next morning, evidently having returned some time during the night. After this date she did not return to brood the young the same night after being flushed from the nest.

In figure 3, sprig-collecting activity has been graphed in relation to the brooding activity of the female. Two modes are discernible—one in the total number of sprigs brought daily, and the other in the total number of sprig-collecting activities each day (indicated by the number of horizontal lines in each daily column). These modes fall in the period of waning of brooding. A possible explanation for them is that the female

is obviously under the influence of estrogen while brooding and that because brooding is physically prevented due to the size and activity of the nestlings, a displacement activity consisting of twig gathering is evoked by the continuing influence of estrogen.

When the female perceived the male in the nest area, she flew to him to obtain the prey item. The male remained perched and the exchange usually occurred when the birds were stationary. On one occasion, Gromme (1935:19) observed the meeting of a pair of Goshawks in flight near the nest. Most likely food was exchanged, but this was not determined. In the present study, there is some evidence to indicate that aerial exchange was occasionally attempted although this was never actually observed. After the "transfer" had been performed, the female fed the young and the male left the area. The female uttered a distinctive call when the male appeared in the nest area. This was used by the investigator throughout the study as an indicator of the male's presence.

An element of hostility was discernible in the "transfer" phenomenon that cannot be accounted for solely by the inherent disposition of falconiforms. The female tolerated the presence of the male in the nest area and often waited expectantly for him to bring food for the young. However, after food was delivered, she would not begin to feed the nestlings until he had left the area. This the male did when the female uttered the "dismissal call."

It is postulated that this phenomenon is a mechanism whereby the male increases his foraging rate so that the food demands of the young can be met. If the male was not expelled from the nest area by the female, he would remain perched near the nest and would not hunt. This was observed on several occasions when the female was absent from the area. The male did not leave until she returned and uttered the "dismissal call." Later in the study, the sight of the female was enough to expel the male.

Transfers of food between male and female continued throughout the study (see table 3: column "T"). Whether the hostility mentioned earlier occurred in this pair during nest-building and incubation periods is unknown. Siewert (1933:53, 56) observed that during incubation the male came to the periphery of the nest area, called, and was met by the female. The male then flew to the nest to incubate the eggs. The female did not return to resume incubation for an hour or so. From these observations, it seems reasonable to conclude that the male is not expelled from the nest area during incubation nor probably during the nest-building period. It may be that when the young hatch, the disposition of the female changes and her actions cause the male to leave the nest area. In the present study, the male flew to the nest immediately after "transfers" for the first four days of observation (table 3: column Tmn). It would appear that this is a carry-over behavior from the incubation period when the male flew to the nest to brood immediately after a "transfer."

BEHAVIOR OF THE FEMALE

Most of the data gathered on Goshawk behavior relates to the female. It was impossible to study in detail the activities of the wide-ranging male. The members of the pair at Donner Lake could not be readily distinguished on the basis of size alone, unless they were observed together at the nest. On closer examination through the 20X telescope, it was found that in this pair the female had wider cross-barring and wider mesial streaks on the breast feathers than did the male, which gave an overall darker appearance to the under parts. These differences were of little use for quick sex determination in observations from the blind. But as I became familiar with activities, differences in behavior afforded unfailing criteria for distinction between male and female.

Defense of the nest area.—The female Goshawk is extremely aggressive in her actions when attempting to drive intruders from the vicinity of the nest. Investigators

Table 1

Numbers and Weights of Prey Items Fed to the Young

	Total numbers	Per cent	Total weight (in gms.)	Per cent
Robin	27	30.7	1285	21.4
Steller's Jay	22	25.2	1356	23.1
Citellus lateralis	6	6.8	700	12.0
Chickaree	5	5.7	594	10.2
Eutamias sp.	5	5.7	226	3.9
Tanager (nestling)	4	4.6	89	1.6
Citellus beldingi	3	3.4	575	9.8
Mallard ducklings	3	3.4	185	3.1
Audubon Warbler	1	1.1	12	.2
Snowshoe Hare	1 (leg)	1.1	100	1.8
Scapanus latimanus	1	1.1	67	1.4
Weasel	1	1.1	45	.8
Williamson Sapsucker	1	1.1	42	.7
Pigeon	1	1.1	140	2.4
Mountain Quail	1	1.1	26	.4
Unknown				
Mammals	5	5.7	399?	6.8
Birds	1	1.1	25	.4
Totals	88	100.0	5866	100.0

who have had only casual experiences with nest sites have been duly impressed by the persistence and abandon displayed in her swooping attacks. Clothes have been torn and wounds inflicted on persons attempting to climb to blinds near the nest (Dixon and Dixon, 1938:5; Gromme, 1935:16, 19). The female may inflict injury in two ways. She may swoop on the intruder and deliver a stunning blow with the feet or she may rake exposed portions of the body with the large hind claw (Sutton, 1925:196).

It was noted in the present study that attacks were less frequent if several persons were in the nest area. In this event, the female's aggression may be limited to several close swoops or merely to aggressively cackling in the tree tops. After each swoop, the female usually takes a position out of sight of the observer and will again move to a hidden position if she is brought into view. Diving attacks are usually accompanied by the aggressive cackle, but in one instance a silent swoop was made on me. Aggressiveness diminishes if the intruder becomes motionless or remains in the area for long periods. The female became more aggressive when I moved to a position between her and the nest. If a white cloth or sheet of paper was raised above the head and waved vigorously, it was possible to frighten the female away from the vicinity of the nest. On such occasions, climbing to the nest or the cackling of the young did not induce the female to return. Aggressive behavior was observed only when humans entered the area. This particular nest was near a camp ground, but human intrusions, other than my own, were noticed only on four occasions.

Call notes.—The female utters a high-pitched note at rapid intervals when defending the nest. The call has been described as *ca, ca, ca, ca* by Sutton (1925:196). These notes are of short duration, three or four being uttered per second. Series of these notes were uttered at varying intervals depending on the aggressive attitude of the female. When the female cackles from a stationary perch, she often turns the head slowly from side to side, causing the sound to seem to change direction.

The second type of call given is totally different from the defense cackle. It is a long, plaintive scream lasting from one to two seconds, first rising and then falling in pitch. This call was given when the male entered the nest area. Three modifications of the call were noted. These have been named (1) the recognition scream, (2) the transfer scream, and (3) the dismissal scream. The names serve merely to distinguish the three types and may only partly reflect functions of the calls. When the male is first sighted or heard in the nest area, the female leaves the nest, uttering the recognition scream, but it consists of shorter, more intense notes which frequently end in a harsh-sounding falsetto tone. It would seem that these occur when the two birds meet for food exchange, but this exchange was never observed. Possibly the male in some instances does not relinquish the food immediately to the female, causing her to call excitedly. A third modification of this call was heard when the male remained in the nest area after the food transfer. The female in this instance would return with the prey item to the rim of the nest and utter the dismissal scream. This call resembles the recognition scream but is given with less vigor. It is uttered in succession with periods of approximately one half second between each call. The first note was usually one half the length of the others. This produced a choked, cut-off scream and a longer pause between the first and second notes than between the second and the third or the third and fourth. In one instance, the female uttered dismissal calls for 10 minutes after the transfer, presumably until the male left the area. Only then was feeding of the young undertaken.

Feeding of the young.—Feeding was performed entirely by the female. She insisted on feeding the young even after they were capable of tearing flesh for themselves, and she would portion out food whenever she brought or found prey at the nest. This behavior could have survival value because when the female feeds aggression among the nestlings ceases and the food is more evenly distributed.

The female held the prey tightly with the inner toes of both feet. The outer toes were used for support and their contact with the nest platform afforded the balance needed while she was tearing the prey. The hooked beak was closed into the flesh and portions of meat were torn away with an upward pull and a simultaneous twist of the head. The food was then held out to the begging nestlings, who struck forcefully at the female's beak, removing the portions of meat. The female's head was often twisted slightly so as to facilitate the nestlings' removal of the food from the closed mandibles.

The length of time involved in feeding depended on the size of the prey and was found to vary considerably. Of 79 feedings, the average period per carcass was 11.5 minutes. The range was 15 seconds to 61 minutes. Sixty-one feedings occupied 15 minutes or less. Usually the entire carcass was fed to the nestlings, exclusive of a few hard parts such as legs, beak, and tail, which were eaten by the female.

If the prey was whole when brought to the nest, the female would usually begin to tear at the head. Only once was feeding observed to be initiated at the posterior end. In one instance, plucking of the prey on the nest rim preceded feeding of the carcass to the nestlings. The item was usually entirely consumed except for the intestine. A special "dislike" was noticed for the intestinal portions of the alimentary tract in most prey items. Other viscera were ravenously eaten, but when the intestine was torn loose from the body, the female would hesitatingly pass a portion of it in and out of the beak several times without swallowing it. It would then be laid aside and later taken from the nest. A somewhat similar attitude was noted when the stomach of a Steller's Jay (*Cyanocitta stelleri*) was torn open. The female put her beak into the exuding contents and scattered them over the nest platform with sideward motions of the head before feeding was continued.

Post-feeding activities.—At the termination of feeding, the female would search for

particles of food which had fallen to the nest platform in the course of the meal. These when recovered would be presented again to the nestlings or eaten by the female. After these "clean up" actions the female often assumed a perching position. This was followed by cleaning the talon on the second toe and wiping the beak on the perch. Cleaning the talon was accomplished by gripping it with the beak and pulling upward. As the claw passed between the maxillary and mandibular tomia, removal of blood and flesh particles was accomplished.

Excavation.—This term has been given to an activity performed by the female at the nest. At times she would stand in the center of the nest cup, extend the beak and head out of sight into the matrix, and then pull and push vigorously at the structure. When she lifted her head, pine needles and debris held in her beak were discharged with a sideward motion of her head. The material was scattered on the surface of the nest platform. Occasionally, objects cleared the nest rim and fell to the forest floor, but this was not a common occurrence. Excavation activities diminished as the season progressed. Like brooding, sprig collecting and some other activities of the female (see fig. 3), excavation activities are probably influenced by the estrogen level.

Sprig collecting.—The method of twig collection was observed in detail. Before leaving the nest the female was often seen to raise and lower the head with "rapid peering" motions as described by Grinnell (1921). She would fly from the nest and alight on a lodgepole pine branch perhaps 50 feet away from the nest and at about the same level. From this position, she walked or flew toward the distal portion of the branch until suitable live twigs were encountered. A twig was gripped with the beak at a place close to its attachment on the branch. It was pulled upward with the same motion used when tearing prey, although the vectors involved differed slightly. In tearing prey, a direct line of pull existed between the feet and the neck muscles. In sprig collecting, the beak, being closed over the twig, was in a slightly more forward position and the line of pull was not directly from the feet. To compensate for this, the female leaned backward and, bracing both feet against the limb, pulled with abrupt movements until the sprig came free. The wings were used to regain an upright posture after each backward thrust and to maintain balance when the twig snapped off. It was then grasped in the beak and delivered to the nest. When the female arrived at the nest rim, the sprig was occasionally placed at a definite spot, but more commonly it was dropped wherever the female happened to land, and even on the nestlings themselves. In this event, utterances of pain were heard and escape reactions were elicited. Once dropped on the platform, no immediate effort was usually made to incorporate the sprig into the nest structure. On one occasion, when a sprig was dropped over the nestlings, the female was observed to push it between them forcefully.

Of 39 sprig deliveries, 18 involved only one sprig and 21 involved two or more sprigs. In figure 3, sprig-collecting activity has been graphed.

Stimuli evoking sprig deliveries were found hard to isolate as several activities were associated with this phenomenon. Sixteen delivery activities were initiated from a brooding position after the female preened or after movement of the young; three followed "excavation" or nest-building activities; eight were not preceded by any identifiable event, and in two the preceding activities were unobserved.

Perching.—While perched, the female was often observed to stand on one leg with the other drawn close to the breast between the feather tracts. This position was assumed frequently during perching activities by both male and female. Such a one-legged stance was preceded by a set pattern of actions. From a two-legged posture, the right leg is lowered until the "heel" joint meets the perch. Then with the toes clenched, the right leg is raised and lowered, striking the perch several times until it is abruptly retracted against the breast feathers.

Stretching.—Immediately after perching, or occasionally before reaching a perched position, a standard stretching activity was performed. The right side of the tail was spread sideward and held rigid. The right leg was then extended stiffly backward and held parallel under the tail. Finally, the right wing was extended downward and back, causing a spreading of the primaries and partial coverage of the fanned tail. Balance was maintained by a slight shift to the left. The tail, leg, and wing were tensely held in this position for from three to five seconds. After relaxation, the normal perching position was again attained. The left side of the body was stretched infrequently.

Table 2

Caching Activity of the Female

Species	Date	Total time food item was cached	Time elapsed since last feeding of the young
Citellus lateralis 160 gms.	June 16	3 hr. 20 min.	3 hr. 20 min.
Citellus lateralis 82 gms.	June 16	4 hr. 40 min.	2 hr. 40 min.
Robin (nestling) 50 gms.	June 18	3 hr.	47 min.
Scapanus latimanus 67 gms.	June 20	9 hr. 20 min.	1 hr. 10 min.
Citellus lateralis 86 gms.	June 24	1 hr. 6 min.	1 hr. 6 min.
Citellus beldingi 103 gms.	June 30	1 hr. 13 min.	1 hr. 13 min.
Chickaree 222 gms.	July 2	6 hr. 25 min.	2 hr. 57 min.
Chickaree 93 gms.	July 6	2 hr. 56 min.	59 min.
Citellus lateralis 42 gms.	June 16	Remained over night.	
Citellus lateralis 176 gms.	June 28	Remained over night.	

Caching of food.—Food items were cached during the early phases of the study when the nestlings were too young to consume large amounts of food at single feedings. The female ceased to cache prey after July 6 when the nestlings were approximately one month old. The female was also seen to cache prey items if a human intrusion occurred while she was feeding the young at the nest. Immediately after the carcass was cached, the female would return to attack the intruder. The caching behavior apparently takes preference over defense of the nest area.

As can be seen in table 2, ten definite instances were noted where prey items were stored in the nest area. Eight of these items were returned to the nest later in the day to be entirely consumed by the nestlings; two were left stored over night and presumably were recovered and eaten on the following day. It was evident that cached items were returned to the nest because the female left the nest and returned within short periods of time with prey. It is doubtful that she had time to forage away from the nest, and her actions when leaving the nest did not indicate that she had sighted live prey within the nest area. Cache returns were not entered in table 2 unless caching of prey was observed earlier in the day. The condition of retrieved items always correlated with descriptions in the notes of items cached earlier in the day. As far as could be determined the female never fed on the cached items while away from the nest.

Carcasses were not always stored at the same location. Direction of departure from the nest indicated at least three storage locations. Six caches were made in an easterly

direction, three were made to the south, and one was made to the west. In three instances where data are available on the directions of cache retrieves, two were from the same direction as that of the original cache.

For seven known instances where the female cached a prey item, she spent an average of 2.7 minutes away from the nest. The average time spent away from the nest in retrieving cached items was 4.1 minutes.

A letter from Dr. John J. Craighead, dated April 18, 1957, describes his observations of a Goshawk caching its food as follows: "The caches were made as close as 100 feet away from the nest and others were several hundred yards away. In every instance the hawk simply wedged the kill in the crotch of a tree, generally one of the smaller limbs. Most of the caches were made in lodgepole pine. Frequently these caches were left for four or five days."

The question arises as to what stimulates the female to retrieve the prey from its storage location. Hunger signs in the young or a timing mechanism in the female could be postulated. If the former stimulus is involved, the time elapsed between the previous feeding and the cache return would be expected to remain fairly constant or to diminish as the season progressed and the food capacity of the young increased. If the latter stimulus is involved, the total time that each item is cached would be expected to remain fairly constant. In table 2, it can be seen that neither of these two postulates holds conclusively, although there is a slight tendency for the times elapsed since the last feedings to diminish. It is quite possible that the hunger level of the female also influences the time of recovery of cached prey.

Foraging.—As already mentioned, the female was occasionally observed to dive from the nest to capture birds or mammals. One mammal and four birds were caught in this manner. A California mole (*Scapanus latimanus*) which apparently came above ground was captured near the nest. An Audubon Warbler (*Dendroica auduboni*) was captured near the ground, approximately 50 feet from the nest. Three young Mallards (*Anas platyrhynchos*) were captured approximately 200 feet from the nest.

This latter event was observed in detail. At 4:15 p.m. the female was perched on a branch three feet from the nest, facing east. She turned around and looked intently toward a partly dried impoundment some distance to the west. The hawk left the nest and swooped to the grassy plot. Immediately the alarmed quacking of an adult Mallard was heard plus the sound of flapping wings. This continued sporadically for about three minutes. Then the Mallard left the pond but continued to quack from a distance. After the hawk landed in the grassy plot, she was observed to walk and hop through the ground vegetation. "Rapid peering" motions were performed and occasionally she would seek a vantage point such as an upraised log or stump. Eventually the entire pond area (approximately 75 by 150 feet) was searched for the hidden ducklings. At 5:26 p.m. the female brought back a partly eaten duckling to feed to the young. The time away from the nest was not spent entirely hunting in the meadow. Twice the female was observed flying to the nearly woods, probably to eat or cache a duckling. Three ducklings in all were fed to the nestling hawks. They were delivered 17 and 34 minutes, respectively, after the first duckling. The female's breast feathers appeared moist and she was observed on several occasions to wade into the shallow water in search of the ducklings.

A similar foraging incident was related to the investigator by a ranger at Donner Memorial Park. He had observed a Goshawk on the ground near his house attempting to flush prey from around brush and logs.

Another observation not exactly pertinent to the discussion of foraging behavior will be injected here. In the early phase of this study, when the female remained close to the nest, a freshly skinned carcass of a *Citellus beldingi* was thrown from the blind. It was sighted by the female and after two minutes of "rapid peering" at the fallen object, she dropped from the nest, retrieved it, and began to feed the young. This incident is not surprising in view of the fact that the female was once observed to recover a prey item

which had fallen from the nest during feeding of the young. It seems highly unlikely that the Goshawk would forage for carrion under normal circumstances.

The female occasionally left the nest area late in the day to hunt. This was evidenced by the fact that she was away from the nest for long periods prior to each of her food deliveries. Seven instances, as listed below, were observed when the female hunted and brought food to the nest.

Species	Time away from nest
Citellus beldingi	2 hr. 42 min.
Chickaree	1 hr. 11 min.
Steller's Jay (nestling)	2 hr. 17 min.
Chickaree	3 hr. 30 min.
Chickaree	5 hr. 56 min.
Chickaree	5 hr. 56 min.
Weasel	8 hr. 26 min.
Chickaree	2 hr. 20 min.

The female often fed on the carcasses that she captured while absent from the nest area. This was proved by the partly eaten condition of the prey delivered and by the gorged state of the female upon her return to the nest.

BEHAVIOR OF THE MALE

The male usually entered the nest area only to bring prey items to the female or to the nestlings. After each delivery, he left the area and was not seen until he again returned with food. During the 19 days of observation, the male delivered food 75 times, an average of 3.9 times per day. Each food delivery was completed in from one to two minutes. Consequently observations on the male are fewer than those on the female.

Defense of the nest area.—Aggressive behavior in defending the nest area is not characteristic of the male. Several observations made in the course of the study support this statement. On one occasion as I entered the nest area and proceeded toward the nest, the male was discovered perching approximately 40 feet from it in a lodgepole pine. He remained in a perched position and watched my approach with unalarmed curiosity. After one minute, he took flight and disappeared. In a second instance, the male remained perched and undisturbed when I made an appearance at the top of the blind, approximately 30 feet from him. A third instance occurred when the male was delivering food to the nest. Before the food was deposited, he discovered my position on the ground below and, clutching the prey, flew off into the surrounding woods. He did not return and attempt to drive the intruder from the nest area as the female would have done. On one occasion, however, the male was heard to give the defense cackle. This occurred after the female had been cackling in a confer above my head for three minutes. The male suddenly came to perch below her and uttered the cackle. It seems likely that this was provoked by the female's actions. When the female heard the cackle of the male, she uttered the "dismissal call" and he left. Other authors (Dixon and Dixon, 1938:4; Bond, 1940:103) have noted aggressive behavior in the male when he accompanied the female around the nest at times of human intrusion. Sutton (1925:194), however, describes the shyness and lack of aggression in the male.

Call notes.—The male is capable of uttering a special note not given by the female (Sutton, *op. cit.*; Siewert, 1933:56). It is an unmusical sound, having somewhat the tone produced by a person snapping the tongue away from the roof of the mouth. In uttering this sound, the male holds the beak wide open and thrusts the head up and forward. When the sound is emitted, the head is brought abruptly downward toward the throat. This is repeated at intervals of five seconds and is audible at distances up to 300 or 400

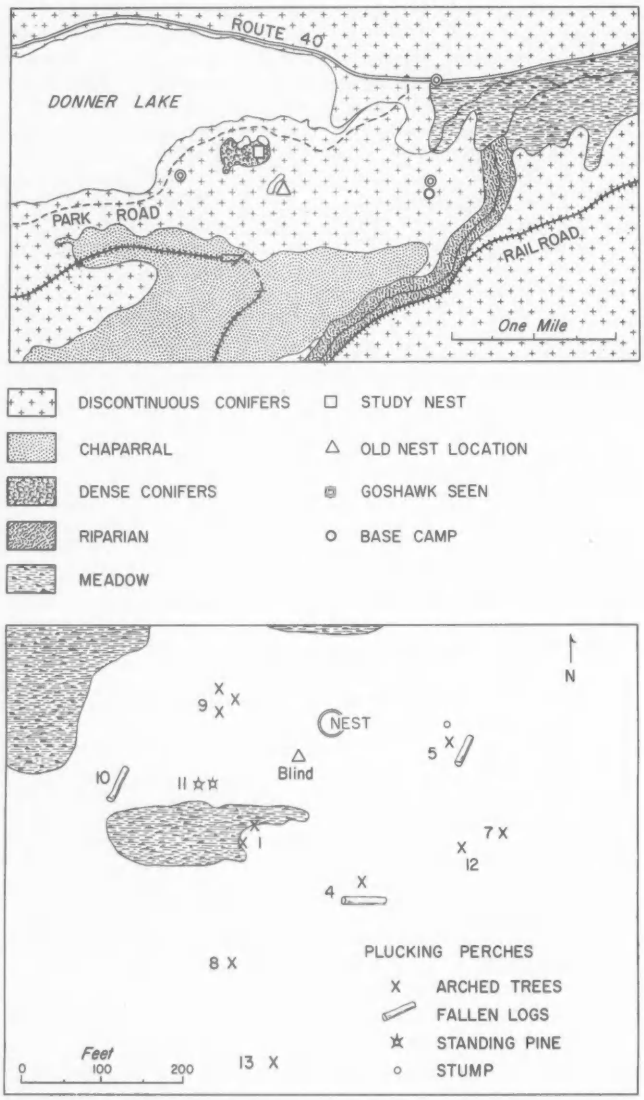

Fig. 4. Upper: map showing location of study nest of Goshawks near Donner Lake, California. Lower: plucking perch locations of Goshawks (see fig. 2).

feet. This call was heard when food was brought to the periphery of the nest area. In this instance, the call indicated the male's presence and his position with regard to the female. A "transfer" usually resulted. The same call was given when the male encountered the female at close range. In this instance, the call appeared to have a social or "conversational" function. The observations of Siewert (*op. cit.*) support these conclusions.

The plaintive scream is often uttered in place of the "guck" call (just described) when the male brings food to the periphery of the nest area. The two calls function in the same way in this situation. The scream never served the function of a social note.

The defense cackle of the male has a throaty quality, is weaker, and is uttered less rapidly than the female's cackle.

Sprig collecting.—One observation was made of the male delivering nesting material to the nest. On July 10, at 11:45 a.m., the male brought food to the nest. The female was absent from the area and consequently the male was able to remain near the nest. Forty-nine minutes later he brought a bare, dead twig, dropped it on the nest rim with a sideward cast of the head, and then left immediately.

Foraging.—On July 7, the male captured a pigeon which I had kept in captivity at the base camp, about one mile from the nest (see fig. 4). When I discovered this kill, a portion of the skull remained, indicating that the hawk had eaten at least the head of the pigeon at the plucking site. On July 8 at 6:26 p.m., 32 hours and 26 minutes after the kill, the male delivered the carcass to the nest. In the interval, the head, shoulders, wings, and breast had been eaten. The male had evidently cached the pigeon on or before July 8 and had continued to hunt for smaller prey during the day. It would appear that the presence of prey cached by the male had some effect on his foraging activities. The total number of deliveries of the male on the 8th were fewer in comparison with those of previous days (see table 3). Possibly the hunger level of the male influences his foraging effort.

It seems unlikely that small prey is similarly retained for such long periods before being delivered to the nest. Two prey items, a nestling Steller's Jay and a Belding ground squirrel, were delivered still alive. Larger prey may be cached and then eaten at intervals by the male. This explains an earlier observation (June 16) when the male delivered only the hind leg of a snowshoe hare to the nest. It is obvious that the male's foraging activities, in some instances, are more complex than merely catching the prey and delivering it to the nest.

Demandt (1938) states that male hawks hunt far from the nest area whereas females hunt somewhat closer. Observations in the present study somewhat support this. The male was seen twice foraging at distances greater than three-quarters of a mile from the nest. Out of 11 prey items brought by the female, five were caught in the immediate vicinity of the nest area, and six were caught outside of a 300 to 400 foot radius from the nest. How far they were captured beyond this point was not known.

I was fortunate to witness the capture of a fledgling robin (*Turdus migratorius*) at the Sagehen Creek station by a male (?) Goshawk that was not a member of the pair studied. The young robin was seen on a dirt road following its parent which was foraging in some scattered sagebrush (*Artemisia tridentata*) about 20 feet away. The Goshawk suddenly burst from concealment, shooting out of a bordering stand of conifers on the uphill side of the sagebrush vegetation. Immediately the adult robin uttered several alarm notes, but before the fledgling could take cover it was captured by the swooping Goshawk. With the fledgling clutched in its talons, the hawk dropped behind a small pile of boulders at the side of the road. Two adult robins continued to call excitedly. I attempted to bring the hawk into view, but in so doing flushed him into the nearby

conifers. The robins followed and continued to call excitedly, thus making the position of the hawk quite obvious. He was standing on the ground about 200 feet from the initial place of the capture, under the trunk of a conifer, and was plucking the carcass.

It seems evident that a male Goshawk returns to nests where more than one nestling have been discovered. This is done immediately after delivering prey nestling to his young. On June 22, two Steller's Jays of the same age were delivered within 21 minutes, and on July 6 two robin nestlings of the same age were brought to the nest within 36 minutes. It seems unlikely that the male could have located two separate nests in either of these instances.

DEVELOPMENT OF THE YOUNG

Growth and age.—Growth curves of the nestling Goshawks were constructed from weight measurements taken from June 25 to July 23 (fig. 5). It was impossible to construct a complete growth curve from these weights because weighing of the young commenced well after the time of hatching. An attempt was made to project the curve in order to establish a hatching date for the nestlings. This was done by calculating the weight at hatching from the egg-weight formula developed by Bergtold (1929) and by superimposing the growth curve of the Golden Eagle, *Aquila chrysaëtos* (Sumner, 1933: 281) onto the Goshawk weights determined in this study. When this was done, the hatching date was estimated to be June 4. The length of time the young spend in the nest is probably from 42 to 47 days (Dixon and Dixon, 1938:11; Siewert, 1933:93). This would place the date of hatching in the present study in the period from June 5 to June 10. To facilitate further discussion, the mid-point of June 7 was taken as the date of hatching of the nestlings at Donner Lake. All ages have been based on this date.

It would seem that two of the nestlings were of the same age and one was younger. This is shown by the weights of the nestlings when they were first weighed. Two weighed 410 grams and 400 grams, respectively, and the other weighed 236 grams. Siewert (1933:92, 93) states that eggs are laid 48 hours apart and brooding begins with the laying of the second egg. If this is so, the smallest nestling was probably two days younger than its nest mates.

In altricial birds, three main stages of nestling growth can be recognized. There is (1) an initial period of rather slow gain in weight, (2) a period of maximum increase in weight, and (3) a final protracted interval of minor fluctuations (Sumner, 1933:284). The growth curves of nestling 1 and nestling 2 leveled off, and that for the male (2) reached the fluctuation stage at a lighter weight than that for the female (1) (see fig. 5). This was probably caused by inherent differences in growth of male and female. The curve form of nestling 3 is not normal. Due to the lack of nourishment, the period of maximum growth was protracted. It would appear that competition for food with the older nest mates commenced at least as early as June 25 (16 days of age), as the weight of the youngest nestling at this time deviated from expected normal growth (see fig. 5). It seems evident that insufficient nourishment from this time on never allowed the growth curve of the youngest nestling to assume its proper form during the period of maximum weight increase. This resulted in a weakened condition and probably was the ultimate cause of death of July 19.

During periods of feeding, the youngest nestling was not receiving as much food as his larger nest mates. This was due to the greater strength of the older nestlings and the inability of the smaller nestling to consume food as fast in a given period of time. After feedings, the youngest was often observed to show signs of hunger while the older nestlings were well satisfied. Throughout the study it was noticed that nestling 3 was listless and slept almost continually.

Behavior.—Behavioral changes in the young were evident from one observation day

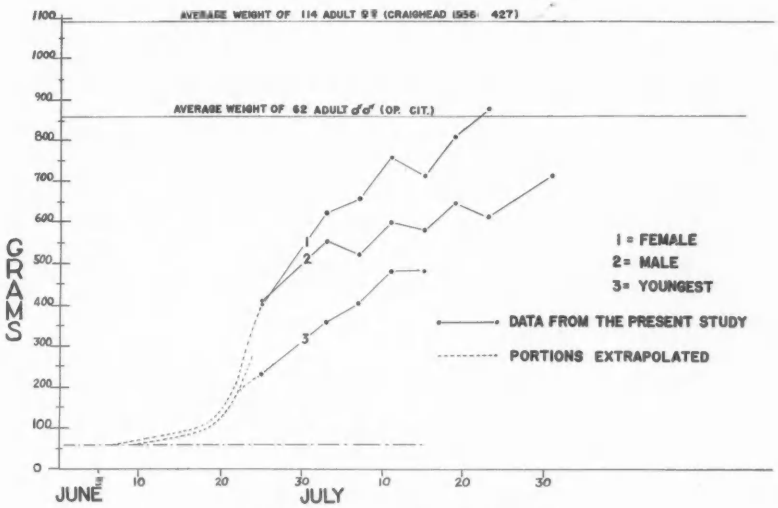

Fig. 5. Growth curves of young Goshawks.

to the next (a period of two days). It was thus necessary to consider nestling behavior on each observation day. The presentation describes for each day of observation only the behavioral events that were observed then for the first time. These activities are not usually mentioned in the succeeding days of observation, althought they may continue to be evident.

The young were color marked on June 25. The discussions for each observation day were drawn mostly from the actions of the older nestlings because they displayed behavior traits sooner and were more active.

Nine days old.—The female brooded the young almost the entire day. At 5:54 a.m. she flew from the nest, leaving the young uncovered. The nestlings were all facing inward in contact with each other. Their heads swayed with uncontrolled, thrashing motions, and in a few instances the beaks of adjacent nestlings came into contact. When this happened one nestling was observed to thrust and poke vigorously at the beak of another. This stimulus and reaction probably directs the movements of the nestlings toward the food held in the female's bill immediately after they hatch.

Call notes were uttered by the nestlings when the female fed them. The sound was a squeaky whistle, lasting about one second, and was barely audible at the blind, 50 feet away. These begging whistles were uttered throughout the meal.

The time that the nestlings spent under the female was related to temperature. In the morning, if one of the nestlings attempted to crawl outside, the female would nudge it gently back under with the beak, or it would crawl back of its own accord. In the afternoon, the nestlings crawled out and slept on the nest platform. One remained out for thirty-five minutes. As the nestlings slept, the female removed insects that alighted on them.

Greater activity was shown from 1:00 p.m. to 8:45 p.m. than from 5:00 a.m. to 1:00 p.m. In the morning, only one defecation was recorded for the three nestlings; in the afternoon three or four were recorded. Increased environmental temperature with a consequent increase in activity of the nestlings explains this difference.

When the female brings food, the nestlings "whistle-beg" and stand unsteadily under the female as she tears at the carcass which is gripped in her talons. She holds food about one and a half inches above the nestlings and waits for them to strike at it. At this age, the young react to a specific

pattern of stimuli when feeding. They will not peck at the carcass nor will they pick up fallen portions of red meat that are lying on the nest floor. Often the nestlings would strike at the female's beak when it was lifted from the carcass whether it contained food or not. The nestlings sometimes strike at the meat held in the beak of one of their nest mates and attempt to snatch it away. The weaker nestling often had food stolen in this manner. If the portion of food received by a nestling was small, it was easily swallowed. A larger piece of meat was only successfully swallowed after a series of contortions. The head was thrown back and the beak pointed upward. With a continuous motion, the head was brought downward to the neck and then extended toward the floor of the nest. These motions were repeated until the food was finally forced into the crop.

Eleven days old.—On June 18, the young were noticeably larger. Coordination was essentially as poor and uncontrolled as at nine days of age. Some improvement was noted during the warmer parts of the day. A general increase in activity was noticeable in comparison with the nine-day-old nestlings. No contour feathers were as yet visible on the nestlings, but a rudimentary "preening" motion was observed. This action was an awkward nibbling at wing, side of neck, and back. Each "preening" attempt lasted only from two to three seconds.

A call note was uttered whenever the nestlings were in pain. On one occasion, it was uttered when the adult female stepped on a nestling. In another instance, the call was given when a nestling became caught between two twigs. The sound is a rapid, high-pitched twitter, resembling the note of a domestic chick when caught and picked up.

The two older nestlings began to display interest in their surroundings. They pecked "inquisitively" at each other and one was observed to pull weakly at a twig in the nest platform from time to time. The youngest nestling did not engage in these activities and slept most of the day.

Thirteen days old.—On June 20, during feeding, the nestlings were observed to strike at the red meat held in the female's talons as she stood on the nest rim and tore at the carcass. This was the first evidence of a change in feeding reactions. However, the young did not pick up fallen particles of food from the floor of the nest.

A reflex motion was used by the nestlings to dislodge insects from their bodies as they slept. The motion was not directed at any particular part of the body and was performed regardless of where the insect caused the discomfort. In this action, the head is thrown violently upward and back against the shoulders. One side of the head, usually the left, is rubbed rapidly back and forth between the shoulders. The entire movement lasts only about two seconds, but it is enough to dislodge a crawling insect. The female performs this same movement when dislodging insects from the head region.

The defecating mechanisms which enable falconiforms to eject the feces outside of the nest are well known. This behavior trait is innate and appears early in the behavior of the nestlings. At nine days of age the nestlings were observed to orient themselves while remaining in prone position so that the trajectory of the feces was directed over the side of the nest. At 13 days, due to the increased development of muscular coordination, the feces were ejected from a standing position. Intention movements could be detected five to seven seconds before the actual ejection of the feces. The nestling would rise and awkwardly maneuver to a position near the rim, facing toward the center of the nest, whereupon the feces would be ejected.

Fifteen days old.—On June 22, the nestlings appeared to be more active and to move about the nest with more facility. They still remained in a crouched position and took unsteady steps when moving from one place to another, often using the wings to maintain balance. Defecation, feeding, preening, and fly-shaking movements had become more ritualized. During feeding, the nestlings continued to strike at red objects. In three instances, the nestlings pecked at the red-orange eye of the female. The nestlings became increasingly aware of objects in the nest. One nestling was observed to peck hesitatingly at a branch and later at its own outstretched toe.

Seventeen days old.—Activities on June 24 were not essentially different from those of the preceding observation day, although one nestling was observed to stand erect for the first time. It took four unsteady steps across the nest and remained standing for about five seconds. All activities prior to this, except feeding and defecation, had been performed from a prone position. The wings of one nestling were extended upward, in a stretching motion. This was the first time that wings were used for any activity except balance while moving in the nest.

Intention movements of defecation were evident 26 seconds before the actual ejection of feces.

Apparently muscular coordination is better developed than at 13 days of age when intention movements were detected 5 to 7 seconds before actual defecation.

Differences in the behavior of individual nestlings became evident. Of the two oldest, one was decidedly more advanced. The youngest was considerably retarded. It was observed to preen for the first time on this date—six days after preening was first observed in the older nestlings. One of the larger nestlings performed mature preening motions on newly emerged pin feathers. It reached back and preened under the wing, using a "nibbling" movement of the beak to slough off scales from the feathers sheaths. It also preened the wing along the ulnar tract.

An awareness of objects away from the nest was noticed on this day. One of the older nestlings watched the motions of the female perched on a branch about three feet away from the nest.

Nineteen days old.—On June 26, the nestlings could be distinguished because color dopes had been placed on their heads the night before. For purposes of brevity, the nestlings will henceforth be referred to by number. The female, the male and the youngest are numbers 1, 2 and 3, respectively.

Behavioral events that were observed for the first time were: (1) Nestling 3 pecked at a twig. This action had been observed eight days previously in the older nestlings. (2) Nestling 1 pecked forcefully at a twig. Pecking activities previous to this observation had been performed in an "inquisitive" fashion. The motion observed on this day was a forceful biting and a twisting of the head from side to side. (3) Nestling 1 peered over the nest rim to the ground below. Improved visual perception was evident. (4) The nestlings uttered a "contentment twitter." The call given was somewhat like the sound of the "pain twitter" but the individual high-pitched, staccato notes were spaced farther apart and the rhythm was uneven. As each note was uttered the body of the bird would bounce. This note is probably analogous to the "conversational chipper" described by Sumner (1934:347) in Golden Eagles. In the Goshawks, the note was often given by the nestlings when they had been well fed and the female was perched nearby.

Twenty-one days old.—On June 28, the nestlings were observed to associate the female's "recognition" and "transfer" scream with the bringing of food to the nest. When the female called as she left the nest, the nestlings uttered food-begging calls. These had been previously associated only with food brought to the nest or with the tearing of the carcass on the nest rim by the female.

Visual perception continued to improve. Nestling 2 was observed to watch the approach of the female when she brought twigs to the nest. Use of the talons was observed in nestling 1. After vigorously pecking at a twig for a short time, it suddenly grasped a twig with its foot. This action is probably a precursor of the "stabbing" reaction which is performed at a later age.

Striking at insects with the beak is evidently a deep-seated response. Nestling 2 was observed to peck at black flies crawling on the head of nestling 3 on this day.

The motions used to regurgitate pellets were observed. From a prone position, the head and neck were thrown from one side to the other. The pellet was seen to be lodging in the crop. After perhaps two minutes, during which time the sideward head motions were continued, the pellet was worked up to the top of the throat. In preparation for its ejection, the head and neck were lowered and pointed into the nest matrix. A final dislodgement of the pellet was effected by vertical pumping motions of the head and neck.

Nestling 1 was seen to peck vigorously at nestling 3. Pecking activities previously had usually been directed to inanimate objects. Such aggressiveness was rarely recorded in the nestling period except at times of feeding.

Twenty-three days old.—On June 30, in the absence of the female, the nestlings (2 and 3) attempted to tear flesh from a prey item. At 2:50 p.m., the male left a nestling robin in whole condition at the nest. Nestling 2 at first pecked inquisitively at the yellow areas at the gape of the beak. Nestling 3 joined in. Most unexpectedly a change occurred in nestling 2. It aggressively attacked nestling 3, uttering a sound resembling the female's cackle in rhythm and tone. Nestling 3 immediately moved to a remote portion of the nest and faced away from the attacker. This call elicited an apparently innate response in both nestlings 1 and 3. They stood up, faced away from nestling 2 and moved to positions on the edge of the nest rim. Their heads and necks were pointed down, almost touching the nest structure. The rumps were above the level of the head and were pivoted toward the attacker. This posture has been named the "defense stance." The function of this posture becomes evident when the method of the feeder's attack is observed. The attacker attempts to strike at the head or neck with

the beak. This is seldom possible if the individual being attacked holds the head low and pivots the rump to block the attacker. Such a reaction would appear to have survival value for the species, permitting weaker nestlings to survive the attacks of larger nest mates during feeding activities.

After attacking the other nestlings, nestling 2 tore small pieces of flesh from the neck of the robin. It was not yet able to feed from a standing position but it managed to tear at the carcass while resting on its abdomen and heel joints and holding the prey in front with both feet. The other nestlings were not able to remain standing for long periods. When they sank to a prone position, the activity caused the feeder to again utter the "aggressive cackle." The "defense stance" was immediately resumed by the attacked nestlings.

When the female arrived and retrieved the carcass from nestling 2, all the young birds clustered below her and their aggressive actions ceased.

On this date, all the nestlings were able to perceive objects away from the nest. They observed the female as she flew to and from the nest.

Twenty-five days old.—On July 2, activities were essentially unaltered from those of June 30. Events observed for the first time were: (1) Nestling 2 used the "rapid peering" motion in sighting away from the nest. (2) Nestling 2 scratched the top of the head with one toe. (3) Nestling 3 was observed to nibble lightly at the head of nestling 1.

Twenty-seven days old.—On July 4, nestling 1 was observed to pivot the tail with a movement identical to that of the female when she was perched or settling on the nest. Although the tail feathers had just begun to emerge from the quills, muscular reflexes responsible for tail movement were evident.

Nestling 3 was observed to grasp the prey left at the nest by the male and give the aggressive feeding call. This caused the others to assume the "defense stance" as was observed on July 30.

Experimental flight motions were first noticed. Nestling 2 initiated the beating motions and was immediately mimicked by nestling 3. Nestling 1 watched closely. Its head was twisted at right angles to its usual position, with one eye pointing toward the nest floor. This has been interpreted by Sumner (1934:349) as a curiosity activity. He believes that it is a method for the attainment of a better perspective. He states: "In the evolution of the habit the youngster [*Haliaeetus leucocephalus*] had gradually come to tip its head more and more until it was rotated nearly 180°."

The nestlings remained prone throughout most of the day. In one instance, the three nestlings were observed to remain standing for an interval of one minute. In the weighing activities at 11:00 p.m. on July 3, the nestlings were seen for the first time to grip the nest tightly when lifted.

The awkwardness previously connected with defecation movements had disappeared. The nestling preparing to defecate stood facing the center of the nest and at the same time moved backward until the edge of the rim was reached. About two to three seconds before the ejection of the feces, the head was lowered, the neck stretched forward, the hind quarters raised, and the wings extended sideward.

Nest-building actions were performed on this day. Nestling 1 picked up a fascicle of pine needles, carried it in the beak across the nest and dropped it on the rim. A vigorous tugging at the nest floor was also observed which might possibly be a precursor of "excavation" activities.

Twenty-nine days old.—On July 6, the "stabbing reaction" (Bond, 1942:84) was seen for the first time. The nestlings while standing erect would suddenly strike out with one foot and grasp a twig that protruded from the nest platform. The twig would be grasped for a few seconds and then released. These reflex actions in adult life enable the hawks to subdue the prey, but at the immature stages the significance and the motivating stimulus of such behavior is not fully understood. Cade (1953:28–30) presents an excellent discussion of the subject. He quotes Rand (1951:525) who states that attacks on inanimate objects may be "at times the attack on an enemy; at times a response to a strange object; at times the result of over-belligerence; and at times play." It would seem that a certain twig configuration elicited a "stabbing response" in the two nestlings. Nestling 2 struck at a sprig lying in the nest; twenty minutes later nestling 1 struck at the same sprig, and after 33 minutes nestling 2 again grasped the same sprig.

Nestlings were now able to maintain a standing position when moving about in the nest, although balance was still uncertain.

In feeding activities, the nestlings had become less dependent on the female. During one feeding, nestling 2 persisted in tearing flesh from the prey held in the female's talons rather than snatch portions which were disarticulated and held in her beak.

Thirty days old.—On July 7, at the time of weighing and measuring, the fear reaction was first observed in the nestlings. When they were brought to the ground, they sat erect with head held back and beak open; the wings were lifted and extended laterally.

Thirty-one days old.—On July 8, no essential differences in nestling behavior were evident. The prey carcass was often snatched away from the female in the course of feeding activities. The nestlings were apparently motivated by conflicting responses. One pattern of reaction was to snatch the food from the female's beak; this created a disposition of docility in the nestling. Another was to tear flesh from the carcass grasped in the female's talons; this caused an aggressive disposition in the nestling. These "conflicting" dispositions were evident when the female fed the young birds.

Sight was well developed at this age. Flying birds and objects dropped from the blind were immediately perceived by the three nestlings. Vigorous attempts at flight were made by nestling 2. The wings were flapped several times and the talons were closed into the nest matrix to prevent the bird from rising from the platform.

Thirty-three days old.—On July 10, fairly skilled nest-building actions were observed. Nestling 2 took a twig in its beak and pushed it with a wiggling motion of the head into the nest rim.

The nestlings exercised the wings more frequently. They were able to raise their weight slightly off the nest platform for periods of one to two seconds. The wings were flapped vigorously and the legs were momentarily retracted as they raised from the nest.

The inquisitive head-twisting motions previously discussed were again observed. In this instance, the head was rotated completely at 180°. This motion appeared to be used as a method for obtaining a better perspective of a strange object (Sumner, 1934:349).

Nestling 1 while feeding on a carcass was observed to swallow a portion of the intestine. The nestling did not show the hesitancy that the adult female had shown in eating intestinal material.

Thirty-five days old.—On July 12, the nestlings were more skillful in using their wings to lift themselves from the nest platform. They were observed to flap vigorously and leap from one location to another as they moved about the nest. These flight actions often took on the appearance of play activities. After a short flight, a nestling would often run back and forth across the nest, playfully.

On this day, nestling 1 was observed to discard a piece of intestine when it was first encountered. Later, however, after the prey was consumed, the intestine was swallowed hesitatingly.

Intense aggressive behavior was observed when nestling 1 was tearing at a carcass on the nest platform. Usually the nestling that was feeding gave the aggressive call, *ke,ke,ke*. This caused the nest mates to assume the defense position and was enough to discourage the others from attempting to snatch the carcass. However, nestling 2 in several instances was observed also to snatch at the carcass. This caused the feeder, nestling 1, to chase after nesting 2 and strike out with the foot.

On this day a nestling first left the nest and perched on a branch about one foot away. It had been chased there by another nestling in the course of feeding.

Thirty-seven days old.—On July 14, a new observation method was attempted from a blind on the ground. Behavior of the young could not be observed in detail. Nestling 2 was seen to perch on one leg and draw the other up against the breast in a similar fashion to that of the female (p. 387).

Thirty-nine days old.—On July 16, observations were resumed in the blind in normal fashion. The stretching movements performed by the female (p. 387) were performed by nestling 2 on this day. The female fed the nestlings once during the day. Large portions of the carcass were given to the young. When each nestling received food, it would turn away from the others to assure retaining possession of the meat. No cackling or other aggressive behavior was shown, however.

Forty-one days old.—On July 18, nestling 1 was observed to walk awkwardly to a branch beside the nest and assume a perched position. The begging call note usually given by the nestlings had become modified and sounded somewhat like the plaintive scream given by the female when she sighted the male in the nest area.

Forty-three days old.—On July 20, only two nestlings remained in the nest; nestling 3 had died on July 19 and apparently had been eaten by his nest mates.

Nestling 1 performed the instinctive spreading reaction, well known in hawks. The wings were lowered and spread and the head was held low. The action occurred when the female returned to the nest and the nestling was feeding on a carcass. Sumner (1934:350) interprets the spreading reaction as functioning to keep the food from the other nestlings and to maintain balance while the feet are

utilized in subduing the prey. In the instance I observed, it would seem that the spreading of the wings and tail obstructs the view of the challenging hawk and usually prevents further aggression.

The nestlings continued to perch on the branches beside the nest throughout the day. Their ambulations to and from the nest were performed with more agility.

Forty-nine days old.—On July 26, the young birds left the nest and were observed to move about through the branches, reaching distances of 50 feet from the nest. Certain "pathways" through the canopy were used. Whether this was because one bird followed the other or because limitations of strength and agility dictated patterns of movement through the trees could not be determined.

When the young birds perched in the branches, most of their time was spent in preening and sleeping with head lodged under the scapulars. They were also observed to remove strips of bark with their beaks from portions of the perch directly beneath them. These actions were often preceded and succeeded by inquisitive head-rotation movements.

Occasionally begging calls were uttered. These calls resembled the "recognition scream" of the female. Such periodic sounds probably enable the adults to locate the young birds when they range to greater distances from the nest later in the season. The "twitter" call, previously uttered only when the nestlings were in pain (p. 394), was given at the initiation of flight or when the fledglings climbed about in the branches.

The fledglings remained away from the nest most of the day except when prey was delivered. The female persisted in feeding the young. On one occasion she captured a chickaree (*Tamiasciurus douglasi*) and fed it to the fledglings. On other occasions, the male brought food to the nest.

Whenever food was brought to the nest by the male or female, the fledglings would immediately return to obtain the prey. At first the return flight was awkward and often several separate flights from one branch to another would be necessary to cover the distance. Later in the day, single flights were accomplished. Such flights were simple glides initiated from a higher level than the nest, resulting in a loss of altitude. Flights of 20 to 30 feet were made. The first nestling to arrive at the nest snatched the prey and usually consumed the entire carcass, attacking the other nestling if it intervened. At first, landings on the nest were awkward, with the fledgling landing in a heap on the top of the prey item. Later, however, more agility was developed and landings were smooth and accurately performed. "Rapid peering" motions preceded each flight or movement from one branch to another.

Nestlings 1 and 2 spent the night perching at points 40 and 60 feet from the ground, respectively.

FEEDING HABITS

The data reported here were amassed entirely by distant observations, with a 20X telescope, of food deliveries, except in three instances when prey items were retrieved by me from the nest. Eighty prey items were definitely identified, three were tentatively named, and three could only be placed in the categories of "bird" or "mammal." Identification of the prey mammals was occasionally hindered when a head was missing or when fur had been plucked from the body.

Several methods were used to determine the weights of prey items brought to the nest. If the prey item was an adult in whole condition, it was assigned an average weight value for the species. These were determined for each species from specimens caught in the area and from data in the collections at the Museum of Vertebrate Zoology. Hall's data (1946) were used in a few instances.

If the prey item delivered to the nest was partly eaten, it was assigned an estimated percentage of the total weight. These estimates were aided by trial removal of various parts of an animal type and by expressing the remainder as a percentage of the total original weight. A *Citellus beldingi* was used to calculate the percentage values for the small mammals, and a Hairy Woodpecker (*Dendrocopos villosus*) and an Oregon Junco were used for determination of the percentage values for birds.

It was often necessary to make allowance for variations in weight due to age in items brought to the nest. For mammals, weight assignments for young individuals presented no problems. Few young mammals were brought to the nest and those that were brought

matched specimens that had been collected in the course of the study. Nestling robins and Steller's Jays of all ages were brought to the nest. Consequently a method was required for the determination of weight for various ages. From study skins of robins and Steller's Jays, age-weight curves were plotted. Wing feather lengths of prey items brought to the nest could be estimated through the telescope and a weight figure could be assigned to each individual by reference to the age-weight curve.

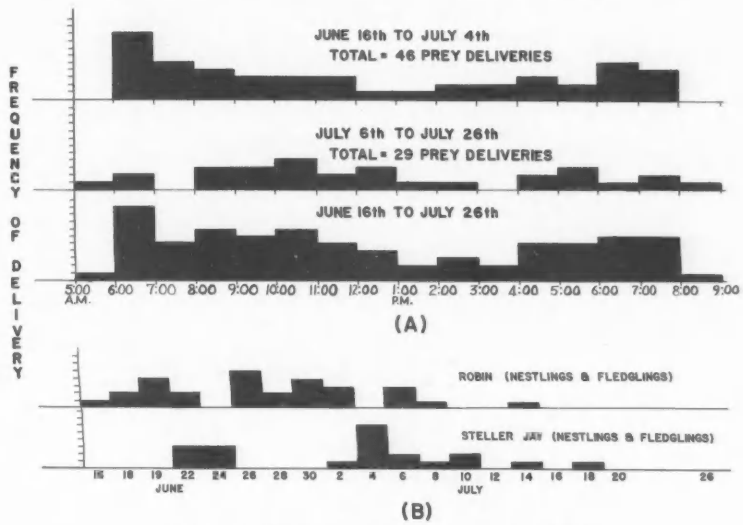
JUNE 16th TO JULY 4th
TOTAL = 46 PREY DELIVERIES
JULY 6th TO JULY 26th
TOTAL = 29 PREY DELIVERIES
JUNE 16th TO JULY 26th
FREQUENCY OF DELIVERY
5:00 A.M. 6:00 7:00 8:00 9:00 10:00 11:00 12:00 1:00 P.M. 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00
(A)
ROBIN (NESTLINGS & FLEDGLINGS)
STELLER JAY (NESTLINGS & FLEDGLINGS)
15 18 19 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 26
JUNE
JULY
(B)

Fig. 6. (A) Daily prey deliveries by male Goshawk.
(B) Seasonal variations in diet of Goshawks.

In instances where the prey could not be identified, the foregoing methods were useless for weight determination. Weight assignments were made in these instances by timing the length of feeding and multiplying by a figure calculated for the amount of food consumed by the nestlings per minute. This figure was determined by recording the length of time taken by the nestlings to consume a prey item of known weight. Small mammals were consumed at an average rate of 5.2 grams per minute, and nestling birds were consumed at a rate of 8.2 grams per minute.

The work of Sulkava (1956) shows that the food habits of nesting Goshawks are best divided into two parts: (1) the prey taken during nest building and incubation, and (2) the animals caught during the period of juvenal development. Adult birds are captured in the first period and nestlings are preyed upon predominantly during the second period. Most probably the shift in the diet is due to the change in abundance of the prey species. If this is true, it would appear that the nestling Goshawks at Donner Lake capitalize on the peak nesting populations of two principal prey species, the American Robin and the Steller's Jay. In view of data gathered from prey deliveries to the nest, it would appear that the robin population reaches a peak slightly earlier than the jay population (fig. 6B). Both peaks occurred when the nestling Goshawks were consuming large amounts of food. A list of food items for breakdown of prey numbers and weights is presented in table 1. From this table it can be seen that the numbers of nestling

birds (60.5 per cent) and the weights of nestling birds (46.1 per cent), account for the largest part of the diet.

Of 87 deliveries of food to the nest, the male accounted for 74 or 85 per cent and the female accounted for 13 or 15 per cent. Of the total weight of prey items brought to

Table 3

Food Deliveries to the Nest[1]

Date	Total	Female	Male	F(ex)	F(in)	Fc	T	Tmn	M[2]	Mt[2]
June 16	5	2	3			2	3	2		
18	6	2	4		1	1	2	2		2
20	7	3	4		2	1	2	1		2
22	6	0	6				4	1		2
24	5	1	4			1	3			1
26	5	0	5				3			2
28	7	3	4		3		1		1	2
30	7	2	5	1		1	1		3	1
July 2	7	2	5	1		1	3?		1	1
4	7	1	6	1			4		2	
6	7	2	5	1		1	3			2
8	4	1	3			1	1		2	
10	6	1	5			1	1		4	
12	3	0	3						3	
14	3	0	3				3?			
16	5	2	3	1		1	2		1	
18	1	0	1				1			
20	3	1	2	1			1		1	
26	5	1	4	1					4	
	99	24	75	7	6	11	38	6	22	15

[1] Key to symbols at column heads: F(ex), female catches prey outside the nest area; F(in), female catches prey in the nest area; Fc, cache retrieve, female returns stored food to nest; T, "transfer," male exchanges food with female; Tmn, "transfer," then male flies immediately to nest; M, male alone delivers food to the nest; Mt, male gives food to the female at the nest.

[2] Columns M plus Mt give the total number of deliveries by the male to the nest.

the nest (5866 grams), the male brought 4838 grams or 82.5 per cent and the female brought 1028 grams or 17.5 per cent.

The daily frequencies of delivery by the male show a slight tendency to fluctuate as the season progresses. Medium daily frequencies were recorded at the initial stages of observation; higher numbers of deliveries were evidenced when the nestlings were at the period of maximum growth and maximum food consumption; medium and low frequencies were again observed just before the young left the nest (table 3; fig. 6A). This increase and decrease could be caused collectively or in part by: (1) changes in prey abundance, (2) the female's behavior toward the male; this could indirectly reflect the increased food demands of the young, and (3) the hormonal state of the male.

The male delivered food to the nest at all hours of the day (fig. 6A). However, it is evident that more deliveries occurred in the early morning between 6:00 a.m. and 7:00 a.m. and in the afternoon and evening from 4:00 p.m. to 8:00 p.m. than at other times. A moderate peak is also evident from 8:00 a.m. to 11:00 a.m. In the course of the observations, 44 deliveries occurred in the morning (5:00 a.m. to 1:00 p.m.) and 31 occurred in the afternoon (1:00 p.m. to 9:00 p.m.). The pattern of daily deliveries was altered

as the season progressed. During the early period (June 16 to July 4), deliveries were more numerous after dawn and immediately before dusk. During the later period (July 6 to July 26), deliveries occurred throughout the day with a slight peak being evident from 11:00 a.m. to 1:00 p.m. (see fig. 6A).

Weight consumed by the nestlings.—The total weight of prey consumed by the nestlings for each observation day has been plotted in figure 7. A peak in the daily weights of prey consumed by the nestlings is evident, but the total rations are highly variable from one day to the next.

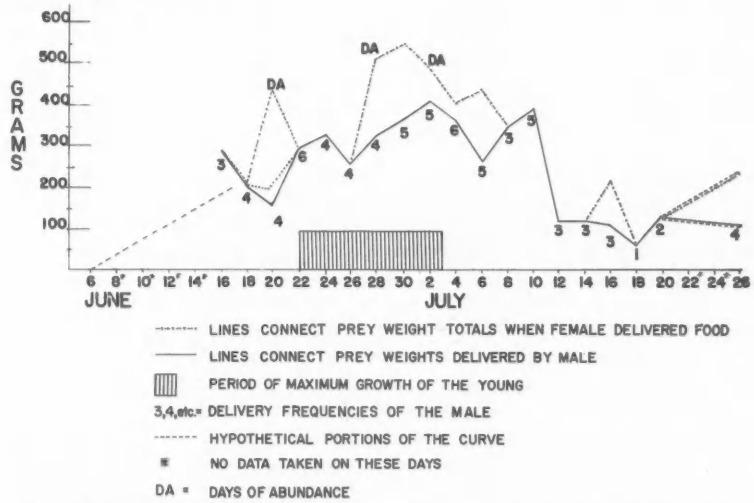

Fig. 7. Food consumption of young Goshawks. Data were not taken on June 8, 10, 12, 14, and July 22 and 24. On these days, the curve was completed by extrapolation. On June 20, dotted lines indicate the form of the curve if a carcass had not been thrown from the blind (p. 389). Days of abundance (DA above) indicate times when food brought to the young hawks was in excess of their daily needs (p. 387).

An observation day was considered one of abundance if the prey was cached and left stored over night. This occurred three times (see fig. 7). One of these days, June 20, can be explained by the fact that a carcass was tossed from the blind by me, retrieved by the female, and fed to the young. The dotted line would represent the curve if this extra item had not entered the daily ration. The two other days of abundance (June 28 and July 2) occurred during the peak period of food consumption. The question arises as to whether prey abundance influences the form of the food curve. More specifically, is the breeding season timed in the Goshawk so that maximum prey abundance occurs when the young are consuming the maximum amount of food and are in the state of maximum growth? Since "normal" days of abundance occur when daily food consumption is at its highest, one would logically conclude that the peak in the food curve is caused by prey abundance. When separate curves are plotted for prey weights contributed by each of the adults (see fig. 7), it is evident that the foraging efforts of the female are mostly responsible for the peaking of the food consumption curve, whereas the male but slightly increases the daily ration at the time of maximum consumption.

Two factors influenced the foraging activity of the female. One of these is prey

abundance in the nest area. As mentioned earlier, the female captured prey in this area; these captures were completely fortuitous and clearly were affected by prey abundance. If the animals had not entered the nest area, they would not have been captured. But after June 30, the female foraged outside the nest area. Subsequent to this date, the increase in daily rations was not necessarily due to maximum prey abundance but was caused by the addition of the female's prey items. The female foraged when the young were most in need of food.

A figure has been determined for the total weight of prey necessary for two nestling Goshawks from the time of hatching until they begin to leave the nest (49 days). Since data on daily rations are absent for two intervals of this period, it has been necessary to sketch in the missing portions of the curve and thereby derive the additional prey weight values (fig. 7). The total estimated weight of prey consumed by two nestling Goshawks during 49 days of development was then estimated to be 13 kilograms.

SUMMARY

The nest of a Goshawk was located in a dense stand of lodgepole pine near Donner Lake, Nevada County, California. Activities of the three young and parents were watched from June 16, when the young were judged to be 9 days of age, to July 26, when the young fledged. The youngest nestling died at 40 days of age, apparently from undernourishment.

Division of labor between the adult male and female was marked. During the initial stages of the study, the female remained close to the nest day and night. She left the nest only to receive food from the male, to capture prey near the nest, to cache prey items, and to collect sprigs to bring to the nest. Her activity changed as the season progressed. Brooding time per day decreased and then ceased altogether; time spent near the nest decreased. After June 30, the female left the nest area to hunt. The female's sprig collecting activity, apparently a displacement behavior, reached a peak as brooding ceased.

The male was responsible for capturing 85 per cent of the food for the brood, but only the female fed the young. She persisted in portioning out food to the nestlings even after they were capable of feeding themselves. The female aggressively defended the nest area from human intruders, but the male showed little concern.

The transfer of prey items from male to female occurred throughout the study with evidence of "hostility" on the part of the female after the food was exchanged. It is postulated that this hostility of the female toward the male is the mechanism which caused increased delivery of prey items by the male to meet the food demands of the young.

Goshawks were observed to capture prey by swooping from a hidden position and by searching in the grass of a small pond for hidden ducklings. Large animals appeared to be cached and periodically fed upon by the male before being brought to the nest; small prey apparently was delivered to the nest soon after capture. The male in foraging, evidently returned to prey nests that contained more than one nestling.

Nestling birds accounted for the largest part of the Goshawks' summer diet. Daily prey weights consumed by the nestlings in the course of the study were recorded, and the peak in daily weight rations was coincident with the period when the food demands of the young were maximum. The peak of the food-consumption curve is caused by the food items contributed by the female. Factors responsible for this increased foraging activity of the female are prey abundance in the nest area and a behavioral change causing her to hunt outside the nest area.

The total weight of prey consumed by two nestling Goshawks in 49 days of development was about 13 kilograms.

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Museum of Vertebrate Zoology, University of California, Berkeley, California, February 1, 1958.

FROM FIELD AND STUDY

A Record of the Laysan Albatross from Southern California.—The Laysan Albatross (*Diomedea immutabilis*) has been recorded from the California coast on but two previous occasions. The first record was the partial specimen secured by C. B. Linton on San Nicolas Island, April 5, 1909, as reported by J. L. Peters (Condor, 40, 1938:90). The second record for California waters was the specimen collected and reported by Karl W. Kenyon (Condor, 52, 1950:100) from 40 nautical miles off Bodega Head in central California, December 6, 1949.

On the afternoon of February 6, 1958, personnel aboard a sport fishing boat in the Santa Catalina

Fig. 1. Laysan Albatross (*Diomedea immutabilis*) captured in Santa Catalina Island channel, five miles off San Pedro breakwater, February 6, 1958.

Island channel, 5 miles off the San Pedro breakwater, noticed a large albatross alight on the water 50 yards away from the ship. The bird swam in close to the fishing boat, and J. E. McClintock succeeded in taking motion pictures of it at close range. The bird appeared to be in excellent physical condition and quite tame, as it readily took live bait offered to it on a hooked line. By means of a piece of fish line looped about its wing, the albatross was hoisted aboard the ship where it readily accepted a dozen live sardines, fed to it by hand. It was brought ashore at Pierpoint Landing in Long Beach where I had the opportunity to examine it and to confirm the tentative identification made by Clyde Paul of the California Department of Fish and Game. The bird, an adult specimen of the

Laysan Albatross (fig. 1), is now sharing a pool with penguins at Marineland of the Pacific, Marineland, California. Aside from the fact that the Laysan Albatross has rarely been recorded from the California coast, it is of interest to find a pelagic species within the relatively shallow shelf waters of the Santa Catalina Island channel.—KENNETH E. STAGER, *Los Angeles County Museum, Exposition Park, Los Angeles, California, February 10, 1958.*

Mourning Dove Breeding in Costa Rica.—Under the name *Zenaidura macroura turturilla*, Wetmore has recently described the southernmost population of the Mourning Dove, which breeds in the western half of Panamá (Proc. Biol. Soc. Wash., 69, 1956:123–126). He mentions that Mourning Doves have been reported from Costa Rica throughout the year, but "no evidence of nesting has come to attention." In preparing my distributional list of Middle American species (Trans. Linnaean Soc. N. Y., 7, 1955:36), I found no record of breeding between Honduras and Panamá. Recently in checking the collection of the American Museum of Natural History to determine what examples belonged to Wetmore's new subspecies, examination of labels on several Costa Rican birds taken by A. P. Smith indicated breeding in that country. Of two adult males from Agua Caliente, altitude 4500 feet, June 2, 1920, one is marked "testes greatly enlarged . . . This bird was shot while sitting on a nest containing 2 eggs ½ incubated." The other is tagged "paired: ♀ escaping." Two birds from Volcán de Irazú, south slope, altitude 9000 feet, May 9, 1920, consist of an adult male labelled "testes enlarged . . . ♂ displaying before ♀ when shot," and a female (with plumage indications of immaturity) marked "ovaries partly enlarged."

These Costa Rican birds can be assigned to the same race as the breeding population of Panamá. Wetmore describes *turturilla* as resembling *marginella* of western North America, but smaller, especially in wing measurements, and as paler than the large eastern *carolinensis* and the small Cuban *macroura*. The Costa Rican breeding birds agree in color with Wetmore's description, although the adult male from the Volcán de Irazú (labelled as displaying) has a richer ventral surface than the others, approaching that of some Cuban *macroura*. In Wetmore's small Panamá series, wing measurements were: six males, 135.2–139.9 mm.; two females, 124.7–129.7 mm. The respective measurements of the four Costa Rican specimens mentioned above for flattened wing were: males, 137.5, 139, 137.5; female, 139 mm. An additional immature male from Agua Caliente, taken June 3, 1920, has a slightly longer wing than the others, 141 mm. Wetmore informs me (*in litt.*) that his measurements were of the wing chord, thus the dimensions of the males from Costa Rica and Panamá correspond very well. The larger size of the Costa Rican female from Irazú may only signify that the range of variation is wider than indicated by Wetmore's two females, or that the cline toward increasing size northward is already apparent in the Costa Rican population. It is even possible that this immature female, taken on May 9, might be a wintering bird of more northern origin. This may be true of another female taken on December 4, 1895, by C. F. Underwood, at Miravalles, Costa Rica. The latter has a wing length (143.5 flat, 142 chord) well within the range given by Ridgway for females of the two migratory northern races and exceeding his average for females of *carolinensis* (U. S. Nat. Mus. Bull., 50, 1916, pt. 7:345, 348). A slightly more deeply colored winter female (January 14, 1890) from Natá, Coclé, Panamá, may also be a northern bird, for the wing is relatively long (140 flat, 138 chord), considering that the longest primary is not quite full grown and the outermost is still in sheath. As both *carolinensis* and *marginella* are reported to winter south to western Panamá (A.O.U. Check-list of North American Birds, 5th ed., 1957:262) and as there is considerable individual variation in these forms, I hesitate to attach subspecific names to these winter specimens.—E. EISENMANN, *American Museum of Natural History, New York, N. Y., March 5, 1958.*

Blue Jay Sitting on Robin Nest in December.—A curious winter incident involving prolonged sitting by a Blue Jay (*Cyanocitta cristata*) on the nest of a Robin (*Turdus migratorius*) is worthy of record.

On December 8, 1955, at 1:20 p.m., I noticed the jay in an old nest of a Robin which was 20 feet up on a horizontal limb of a white birch on the campus of Indiana University at Bloomington, Indiana. The day was cloudy with a very light northwest wind; the temperature at the time was 38°F., the mean temperature on that date was 32.5°. I watched the nest, which was opposite a window of my office and directly over a heavily traveled walk, for the next two and one-quarter hours. During this period,

the jay sat steadily and engaged in behavior typical of that of incubating passerines. Thus, on five occasions for intervals of from five to ten seconds, it rose slightly to probe into the cavity of the nest with its bill; once it seemed to be using its feet as though to adjust eggs. After each probing the jay settled down with precisely the slight lateral shaking and shifting characteristic of a bird placing its incubation patch against eggs. Twice when it settled it changed the direction in which it faced. There were three interludes of restlessness and of turning the head to survey the surroundings; these ranged in length from five seconds to one minute.

At 3:50, returning after 15 minutes' absence from the office, I could detect no change in the bird's position. Frequent observations during the next hour, until dusk, revealed the jay on the nest, sitting as before. At 10 p.m. it was still present.

On the following day, December 9 (cloudy; mean temperature 26°F.) I left the city, having first determined that the Blue Jay was off the nest. A great number of notes and times supplied by my colleagues disclose that it remained away until just before 1 p.m. and that it then sat, probably continuously, until dusk at about 4:30. It was not there at 10:30 that night, nor did I ever see it again.

The location of the nest tree in a busy area precluded any attempt to collect the bird, and it prevented my removing the nest until the students left the campus for vacation some ten days after the foregoing episodes. At that time there were no eggs, the presence of which I had thought barely possible; there were traces of fresh droppings in the cavity.

While I have not infrequently seen Blue Jays sitting motionlessly from early or mid-afternoon onward at winter roosting sites in evergreens, the exposed and busy location in this case as well as the occurrence of acts associated with incubation clearly differentiate the described behavior from mere roosting. I would suggest that what was seen was fundamentally roosting, into which elements of incubation behavior were introduced as the result of the visual and tactile stimuli of the nest. Perhaps collection and examination of the bird might have given some answer to the question as to why the nest had such stimulus value.—Val Nolan, Jr., *Indiana University, Bloomington, Indiana, March 22, 1958.*

Additional Notes on the Purple Martin in Utah.—In a publication dealing with new and unusual records of Utah birds, Behle (Wilson Bulletin, 64, 1952:28) refers to the scarcity of information relative to the occurrence of the Purple Martin (*Progne subis subis*) in Utah. It seems pertinent, therefore, to refer again to some published notes on the subject, not mentioned by Behle, and to place on record some additional information from field observation over the past several years.

My own published records include the following: Wilson Bulletin, 47, 1935:162; Great Basin Naturalist, 2, 1941:3–4, mentioning nesting records for June 21 and July 3, 1937; and Great Basin Naturalist, 6, 1945:71–72. Bee and Hutchings (Great Basin Nat., 3, 1942:76) also published a nesting record for June 25.

The writer first observed Purple Martins on Mt. Timpanogos, Utah County, June 22, 1931, when a male and female were collected at a place known as Mule Flat about two miles north of Aspen Grove Camp. These specimens are now in the Brigham Young University Collection. Following that time two or three pairs of martins were consistently seen, and later found nesting, in that same area at least up until the beginning of World War II. This is an area of aspen forests with open clearings and abundant water. The birds were frequently seen feeding over a small pond nearby.

During the war or shortly afterward a cabin, occupied in summer by sheep herders, was built in the nesting area. Many of the larger aspens suitable for nests of the Purple Martin have been cut for firewood, and the writer has observed no martins in the area since.

A pair of martins was also observed consistently from 1936 to 1941 in an area about three miles north of the above mentioned site at Big Tree Camp, Mt. Timpanogos. They apparently nested in the dead top of a large white fir, but a positive record of their nesting was not established. A single female was noted May 22, 1957, at Utah Lake west of Provo, Utah County, perched on a telephone wire with a flock of several species of swallows. Between June 5 and 7, 1957, a pair of Purple Martins was seen each morning feeding over a small reservoir about five miles west of Colton, Utah County. There were aspen groves in the area with large trees suitable for nesting sites but no nests were located. Several birds were also seen feeding over meadows adjacent to Beaver Creek about eight miles east of Kamas, Summit County, May 30, 1936.—C. Lynn Hayward, *Department of Zoology, Brigham Young University, Provo, Utah, February 27, 1958.*

Some Additions to the Avifauna of Guerrero, México.—During the summers of 1952, 1953, and 1954, field parties from the Agricultural and Mechanical College of Texas, working in the central part of Guerrero, México, obtained specimens of several species which to our knowledge have not been reported from that state. None of the first four species listed below is reported from Guerrero by Friedmann, Griscom, and Moore (Pac. Coast Avif. No. 29, 1950) nor is any of the last three mentioned by Griscom or Moore in their respective chapters of Part II of the "Distributional Check-list of the Birds of Mexico" (Pac. Coast Avif. No. 33, 1957). All specimens are deposited in the Texas Cooperative Wildlife Collection. We are grateful to Robert W. Storer for his counsel relative to the publication of several of these records.

Harpagus bidentatus. Double-toothed Kite.—A first-year male, taken in tropical deciduous growth at about 2900 feet elevation near Agua del Obispo on June 11, 1954, was molting into adult plumage. An immature female of this species (Mus. Vert. Zool.) was taken by W. W. Brown at the nearby locality of Mazatlán on July 8, 1941.

Otus guatemalae. Vermiculated Screech Owl.—An adult male in rufous phase and a juvenal male, taken at Acahuizotla, 2800 feet, on June 24, 1952, and a semi-rufous female, obtained in the mountains west of that village on June 26, 1953, appear to represent the race *hastatus*.

Asio stygius lambi. Stygian Owl.—A male (TCWC no. 5478) taken by G. W. Griffith, 2 miles west of Omilteme, 7900 feet, June 9, 1953, is blackish dorsally. Its wing length, 340 mm., and tail, 173 mm., agree with measurements of this form published by Moore (Proc. Biol. Soc. Wash., 50, 1937:104).

Chordeiles minor. Booming Nighthawk.—A female obtained at Agua del Obispo, June 11, 1954, had one regressing follicle 3 mm. in diameter. A male was taken at this locality on June 22, and "booming" was heard on June 11 and 12, 1954. On June 27, a male was shot from a flock of about 15 of these nighthawks which were flying back and forth along a valley 2½ miles south of Almolonga, 5600 feet. These birds called nightly from June 25 through July 1, but the diving display was not noted. Selander and Alvarez del Toro (Condor, 57, 1955:144) assigned these specimens to the race *neotropicalis*.

Trogon collaris. Bar-tailed Trogon.—Two males and one female were obtained from the mountains about 10 km. west of Acahuizotla, June 11, 1953.

Parula pitiayumi. Tropical Parula Warbler.—A female with largest ovum 8 mm. (TCWC no. 5664) was taken 1 km. west of Acahuizotla, on the interior slope of the Sierra Madre del Sur at about 3200 feet elevation, on June 11, 1953. It was found in broad-leaved riparian trees in the lowermost part of the pine forest. The plumage is too worn to permit satisfactory assignment to race.

Dendroica graciae. Grace Warbler.—Several family parties were encountered in pine forests about Agua del Obispo, 3300 to 3500 feet, June 17 through 20, 1954. Three adults (two females, one male) appear referable to the nominate race on the basis of the whitish posterior extremity of the superciliary stripe and the restriction of yellow on the throat.

Four of these records of occurrence (two owls and two warblers) extend the ranges of the forms concerned to the southward, whereas *Harpagus* and *Trogon collaris* (Griscom, Bull. Mus. Comp. Zool., 103, 1950:353) are not known to occur regularly on the Pacific slope of México.—KEITH L. DIXON and WILLIAM B. DAVIS, *Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station, Texas, March 13, 1958.*

Abalones Eaten by Bald Eagles.—The Bald Eagle (*Haliaeetus leucocephalus*) has such a varied diet (Bent, Life Histories of North American Birds of Prey, Part 1, 1937:343), that it may not be surprising that the Japanese Abalone (*Haliotis kamschatkana*) is evidently a part of it. While sampling a slope muskeg in northern British Columbia with Dr. Calvin J. Heusser of the American Geographical Society, New York City, a number of abalone shells were found where Bald Eagle feathers were scattered about.

This occurred near Namu, Fitzhugh Sound, British Columbia, on August 14, 1956. The spot where the shells and feathers were found was about 300 yards inland from a steep, rocky, tree-lined shore, at an elevation of 125 feet. The site was surrounded by lodgepole pine (*Pinus contorta*), western hemlock (*Tsuga heterophylla*), and red cedar (*Thuja plicata*), and with no access to the water except by air or through dense forest. The general area was isolated with absolutely no evidence of human

disturbance. The number of old and new shells, the feathers, and the liberal amount of excreta indicated that the spot was well used. The evidence showed that at least one Bald Eagle gathered abalones, just how and in what state is not known, and brought them to this spot to eat.

I would like to thank Dr. Arthur Staebler, Fresno State College, and Mr. Richard C. Banks, University of California, for checking the identification of the feathers, and Dr. Keith Woodwick, Fresno State College, for checking the identification of the shells.—ALBERT C. HAWBECKER, *Fresno State College, Fresno, California, March 25, 1958.*

American Redstart in Santa Barbara County, California.—On September 8, 1957, a female American Redstart (*Setophaga ruticilla*) was seen in Cold Spring Canyon (below Mountain Drive) near the city of Santa Barbara. It was actively feeding in California live oaks and was under binocular observation for about 20 minutes. Four days later, and about one-fourth mile from the site of the first observation, a male of the same species was observed feeding in live oaks with a flock of bushtits. A male, possibly the same one seen previously, was feeding in the same locality on the morning of September 16. Although these are sight records, acquaintance with the species in the eastern and midwestern states supports our belief in the correctness of the identification. The American Redstart has not previously been recorded from Santa Barbara County (Grinnell and Miller, Pac. Coast Avif. No. 27, 1944:419).—CHARLES H. RICHARDSON and ALICE I. RICHARDSON, *Santa Barbara, California, April 1, 1958.*

Indigo Bunting Breeding in Los Angeles County, California.—On June 10, 1956, while checking finches present in the *Adenostoma-Salvia* association in Soledad Canyon, I heard a strange song which proved to be that of a male Indigo Bunting (*Passerina cyanea*). Its mate and nest were located in black sage (*Salvia mellifera*). The nest contained two whitish eggs of the bunting and one of a cowbird (*Molothrus ater*) which was removed. One week later the male was observed periodically for two hours as it sang from various perches within six to twenty feet of the nest. The female, which was then incubating, was thought possibly to be a Lazuli Bunting (*Passerina amoena*). A few days later we were successful in capturing the female. We made measurements and photographed her. This evidence later conclusively identified her as a Lazuli Bunting. The eggs proved sterile, and both members of the pair had deserted the area by July 3. The nest and the two eggs were taken to the Los Angeles County Museum.

In 1957, on June 8, a male Indigo Bunting was again found in the same area several hundred feet distant, and on the opposite side of a butte, from the territory of 1956. There it proclaimed its territory from several perches. Six days before, a male Black-chinned Sparrow (*Spizella atrogularis*) had undisputed control over the same territory and had used three of the same song perches. On the 8th and 10th no Black-chinned Sparrow was present on the territory, nor even on that side of the butte. The Indigo Bunting had apparently arrived during the week and was unmated up to the 10th when it was netted, photographed and retained as a specimen. It was presented to the Los Angeles County Museum where it is now no. 29045 in the collection. This specimen is the second for the state of California (for the first, see Cardiff, Condor, 53, 1951:100); there is no previous breeding record. The westernmost breeding record appears to be that of the Dearings (Condor, 48, 1946:139) from Oak Creek Canyon, Arizona.—DON BLEITZ, *Bleitz Wildlife Foundation, Los Angeles, California, April 30, 1958.*

Diving of a Captive Common Eider.—Very little has been published on the method of underwater locomotion of the Common Eider (*Somateria mollissima*). Bent, in his "Life Histories of North American Wild Fowl" (1925:89), states that "in diving the wings are partially opened and used to a limited extent in swimming under water, but the wings are not wholly spread; progress seems to be made mainly by use of the feet, and there is nothing like the full subaqueous flight practiced by some of the Alcidae." Phillips (A Natural History of the Ducks, vol. 4, 1926:91) says "there is no question but that Eiders use their wings under water, whether or not they are wounded . . . . The Eider uses its wings just as does the Harlequin, held close to the sides and beaten with short jerks, not extended as in aerial flight." Schiøler (*in* Millais, British Diving Ducks, vol. 2, 1913:17) described the under-

water activities of the Common Eider as follows: "Several times I have succeeded in seeing them swimming deep down in the dark bright water; the white back was visible, but the position and the movements were not seen until these birds came nearer to the surface. The neck was slightly curved and inclined backwards, the wings were half opened, and the feet working alternately. I cannot say whether they fly under water using the wings in moving forward; in these cases a faint movement of the wings could be seen, but of course the birds were being pursued. The wings were not outstretched, only lifted away from the body, and the tips were pointed behind . . . ."

On January 23, 1958, Kenneth Parkes and I watched the diving activities of a pinioned female Common Eider in an outdoor pool at the Highland Park Zoo, Pittsburgh, Pennsylvania. This bird had hatched from an egg shipped from Iceland. The pool in which she was feeding was three to five feet in depth. Submergence was accomplished by throwing down the head and neck, paddling with the feet, and moving the half-folded wings. The eider invariably submerged with a stroke of the half-folded wings. As the bird disappeared beneath the surface of the water, the wing tip could be seen slightly away from the body. Mergansers, goldeneyes, pochards, and often scoters submerge by leaping forward and slightly upward in a graceful arc before disappearing beneath the surface; the wings are not used. I have never seen an eider submerge in this way. This eider—and others I have watched—dived from the surface without an initial leap forward and always used the wings.

Wings and feet were used for propulsion during submergence and while the bird was going obliquely down to the bottom. However, while it was searching for food on the bottom, the feet alone were used for propulsion. The half-folded wings during this time were held slightly away from the body; they probably served to increase the surface area of the bird, making it easier for the bird to resist the upward force of its own buoyancy. This resistance to the upward force of buoyancy is probably enhanced by the rapid forward movement of the bird as it twists and turns, propelled by swift strokes of its feet, searching out food on the bottom.

The return to the surface of the water was accomplished in a fashion similar to that described for the Surf Scoter (Humphrey, Auk, 1957:392–394). Buoyancy seemed to be the main cause of the bird's rise to the surface; the wings were held motionless, half-folded, and slightly away from the body. I could not see the feet but suspect that they too were motionless. The tip of the bird's beak was held near the breast. The eider varied in its return to the surface; this was perhaps because the water was only between three and five feet deep. Both the angle of the long axis of the bird's body and the angle of the bird's path to the surface varied. Sometimes the long axis of the body was almost horizontal; at other times it was perhaps 15 or 20 degrees from the vertical. The path of the bird's ascent varied from oblique to almost vertical. The head always surfaced first. On reaching the surface the bird tipped forward bringing its head up to its normal resting position and then folded the wings into the "wing-pouches," formed by feathers of the sides and flanks.

Eiders are able to forage on the bottom efficiently at depths as great as 40 feet or more. Describing the feeding habits of the Common Eider, Bent (*op. cit.*: 87–88) says "Eiders obtain their food . . . by diving to moderate depths . . . . They prefer to feed at low tide when the food supply is only a few fathoms below the surface; they often dive to depths of 6 or 8 fathoms and sometimes 10 fathoms . . . ." Madsen (Danish Review of Game Biology, 1954:166) says that the Common Eider probably does not dive much deeper than 10 to 15 meters.

Eiders—and possibly other birds which can dive deeply—seem to be adapted to making efficient use of their limited time under water by budgeting the various energy-consuming locomotor movements in the most economical fashion. The trip from the surface to the bottom is made as rapidly as possible, using wings and feet for locomotion; this is expensive from the standpoint of the energy required. Foraging on the bottom requires finding food as rapidly as possible; but the longer the bird is able to stay at the bottom the more likely it is that each dive will be successful. Finding and capturing food, then, requires covering as much territory as possible as economically as possible from the standpoint of energy consumption. The eiders apparently accomplish this by using only the feet for forward movement and efficiently counteracting the upward force of buoyancy with the half-folded, motionless wings which act as hydroplanes. The return to the surface of the water seems to be accomplished without active use of either wings or feet. The upward force of buoyancy lifts the bird to the surface with the motionless wings and feet acting as hydroplanes. This last phase of the dive requires the least amount of energy and hence allows maximum use of energy for foraging on the bottom.

I am grateful to Kenneth C. Parkes, S. Dillon Ripley, and Peter Stettenheim for helpful comments and suggestions.—PHILIP S. HUMPHREY, *Peabody Museum of Natural History, Yale University, New Haven, Connecticut, April 22, 1958.*

Food of the American Merganser in Unakwik Inlet, Alaska.—The American Merganser (*Mergus merganser americanus*) is an abundant species which breeds in the vicinity of Unakwik Inlet in the northern part of Prince William Sound, Alaska. During the first 10 days in July, 1957, 13 broods, varying from 3 to 6 juveniles and attended by an adult female, were seen in nine tributary streams of Unakwik Inlet, including Cedar and Wells Bay, near 61° north latitude and 147° 35′ west longitude. Additional broods were seen, but not recorded, subsequent to this date. Since these streams are important spawning areas for salmon, it is of value to know what effects the feeding of the American Merganser have on salmon. Consequently a study was conducted during July and early August, 1957, to determine the importance of salmonoid eggs and fry in the food of the merganser in this area.

The summer of 1957 was extremely dry in the region about Prince William Sound. Because not much snow fell during the previous winter, run-off was very restricted. Many streams that had a foot of water in 1956 had only a few inches of water at the same time in 1957. Although these conditions were probably detrimental to both spawning fish and fingerlings returning to the sea, the magnitude of their effects is unknown. The "run" of pink or humpback salmon (*Oncorhynchus gorbuscha*) in Prince William Sound was very late, and it was the smallest recorded in 47 years. Unlike the red salmon (*Oncorhynchus nerka*), the pink and the chum or dog salmon (*Oncorhynchus keta*) spawn in streams which are short in length or even in the "salt-chuck" near the mouths of the streams. Since the fry from these salmon return to the sea during the early spring run-off, it is likely that the bulk of the young salmon had migrated out of the sound before the study was initiated.

Forty adult and 15 juvenal mergansers were shot for study purposes between July 16 and August 5. The ducks were collected either near or within a short distance above the mouth of one of the nine tributary streams in Unakwik Inlet where adults and broods were seen most frequently. Only part of the birds from any area were collected, an entire brood was never killed, and a female with a brood was shot only if the juveniles appeared large enough to care for themselves. When a group of mergansers was approached with a skiff, the juveniles seldom dived but retreated in a compact group. After they were about three-fourths grown, they separated occasionally but dived very infrequently. Adult males in eclipse plumage became very wary after being shot at and occasionally left the water attempting to escape into timber and other cover on shore. After a bird was collected, its tail and bursa of Fabricius were examined to corroborate its age, and its gonads were examined to verify its sex. The bills of juvenal mergansers seemed rubbery, whereas those of adults were hard and would not bend. Also, the legs of adult females were pink; those of juveniles were dull yellow. The esophagus and gizzard of each bird was removed, labeled, placed in a cheese cloth sack which was tied shut and put into a container with 10 per cent formalin.

Upon completion of the field work, the food items from each preserved specimen were separated, and when feasible, these items were counted or measured by displacement of water to the nearest tenth of a cubic centimeter. All food items, tabulated in order of their most frequent occurrence in the 55 ducks, are presented in table 1.

Three hundred ninety-four otoliths, or ear stones of fish, occurred in 44 of the 55 mergansers. The otoliths were probably taken from the bottom of streams or the inlet, since they ranged from 8 to 12 millimeters in length and were probably from fish too large for a merganser to eat. The size and general appearance of the skeletal parts in the unidentified fish materials, which occurred in 32 different mergansers, suggested that most of these materials represented cottoids. Twenty spiny-headed worms (Acanthocephala) were found in six different ducks, 13 roundworms (Nemathelminthes) occurred in four ducks, and two tapeworms (Platyhelminthes) were found in two ducks. Since all of these worms occurred in gizzards and none was attached, they probably were in fish that had been eaten.

Although the availability of the foods taken by these mergansers was not determined, some of the mergansers collected were definitely feeding where salmon had spawned recently or were spawning. Since there were only 48 salmonoid eggs in seven different mergansers, and since only three mergansers had taken about three salmonoid fry, it must be concluded that the feeding habits of the American

Table 1

Food of American Mergansers in Southeastern Alaska

Food items	Number of ducks in which item occurred	Total number of items	Total volume in c.c.
Grit	55	....	97.2
Otoliths or ear stones of fish	44	394	7.2
Unidentified fish materials, mostly skeletal parts	32	....	83.3
Unidentified plant materials, mostly decomposed	18	....	2.8
Crustaceans, unidentified	17	....	....
Feathers, mostly down	17	....	....
Cottidae, sculpins	13	....	69.0
Spirontocaris sp., shrimp	12	....	54.5
Algae	9	....	1.5
Salmonoid eggs	7	48	....
Gastropoda, snail	7	30	....
Bark or wood materials	7	....	....
Acanthocephala, spiny-headed worms	6	20	....
Myoxocephalus polyacanthocephalus, great sculpin	5	....	61.0
Lamellibranchia, clams	5	....	....
Lichens	5	....	2.3
Nemathelminthes, round worm	4	13	....
Salmonoid fry	3	....	....
Gasterosteus sp., stickleback	3	....	9.0
Chironomidae, fly larvae and adults	3	....	....
Anoplorchus purpurescens, crested blenny	2	....	14.0
Platyhelminthes, tapeworm	2	2	....
Diptera, fly larvae and adults	2	10	....
Moss	2	....	....
Osmeridae, smelt	1	....	4.0
Hemigrapsus sp., shore crab	1	....	2.5
Neosphaeroma sp., sow-bug	1	1	....
Isopoda, sow-bug	1	1	....
Chilopoda, centipede	1	1	....
Coleoptera, beetle larva	1	1	....
Antritrichia sp., moss	1	....	1.5
Picea sitchensis, Sitka spruce needles	1	....	....
Tsuga sp., hemlock needles	1	17	....

Merganser were insignificant to salmon in Unakwik Inlet during the period in which they were studied.

Acknowledgment is made to the following people who helped identify the food items: Dan L. Campbell, Betty and Noe Higinbotham, Richard A. Parker, W. M. Walter, Charles W. McNeil, and Ronald H. Alvarado of the State College of Washington, Craig McFee of the University of Idaho, and Lauren R. Donaldson of the University of Washington.—Lee E. Fritsch and Irven O. Buss, *State College of Washington, Pullman, Washington, 1957.*

An Ancient Cormorant from Nevada.—In the summer of 1957, Phil C. Orr, Director of the Western Speleological Institute, asked me to examine a bird skeleton from Crypt Cave in Pershing County, Nevada, collected by the Institute on a joint expedition with the Nevada State Museum. According to Orr's mimeographed report of the Eighth Lake Lahontan Expedition of June-July, 1957, this skeleton and other bones (of small birds and rodents, and a large cat) were found in sediments of the ancient Lake Winnemucca that have been radiocarbon dated as older than 20,000 years.

On examination of the bird skeleton, it was found that, in addition to the disarticulated elements that apparently belong to one individual, there are two separate, unpaired tibiotarsi representing two other individuals. Although one of these tibiotarsi is too fragmentary for specific identification, it is obvious that all bones belong to the genus *Phalacrocorax.*

The elements that compose the one nearly complete skeleton include paired wing and leg elements

with girdles, and most of the axial skeleton, with the skull. All of these bones, and the one complete, unpaired tibiotarsus agree in conformation with Recent specimens of *Phalacrocorax auritus,* the species of cormorant now found in Nevada, and I have no hesitation in assigning the cave bones to this species. However, I find that they do not agree precisely with bones of Recent *P. auritus albociliatus,* the race that is recorded from Nevada today. The tarsometatarsus and tibiotarsus are longer, both actually and relatively to wing bones than in any specimens of Recent *P. a. albociliatus* in the collections of the Los Angeles County Museum, California Museum of Vertebrate Zoology, United States National Museum, or the Zoology Department of the University of California at Los Angeles. In this connection, I extend my thanks to Dr. Loye Miller and Dr. A. Wetmore for their cooperation in carefully checking and measuring the cormorant specimens in the Museum of Vertebrate Zoology and the U. S. National Museum, respectively. Some Recent specimens equal or exceed the paired cave bones in length of humerus, femur, carpometacarpus and ulna, but none equals in length the tarsometatarsi or tibiotarsi. The unpaired tibiotarsus from the cave is even longer than the paired specimens. It might be noted that the tibiotarsus in *P. penicillatus* is a very large element, but, as stated above, the characters of the cave bones are clearly those of *P. auritus.*

In view of the age of the Nevada sediments in which the cave bones were found, it is not surprising to find a difference between the ancient representative of *P. auritus* and the subspecific form known in the area today. The racial divisions of *P. auritus* would be expected to have undergone some change or shifting during a period of 20,000 years, and those recognized today may not have been distinguishable, as such, 20,000 years ago.

As a possible clue to previous distribution and racial differentiation, I felt it advisable to make comparison with two neighboring races, namely, *P. a. auritus* (recorded as far west as Great Salt Lake, Utah) and *P. a. cincinatus* which meets the range of *albociliatus* in the state of Washington (see Jewett *et al.,* Birds of Washington State, 1953:81–83). Two skeletons of *P. a. auritus,* from Minnesota

Table 1

Skeleton Measurements (in Millimeters) and Proportions (in Per Cent) for *Phalacrocorax auritus*

	Nevada cave skeleton	*P. a. albociliatus*[1] min.	max.	*P. a. auritus* U.S. Nat. Mus. nos. 19262	290156	*P. a. cincinatus*[2]
Measurements of greatest length (except as indicated)						
Femur	61.9	57.1	62.3	57.0	62.7	.....
Tibiotarsus (to articulations)	112.4[3]	103.3	107.2	100.2	105.0	112.4
Tarsometatarsus (to articulations)	68.8	61.7	65.8	62.0	64.0	67.7–73.2
Humerus	155.4	148.0	157.3	148.0	154.5	.....
Ulna	164.8	159.0	165.0	155.0	162.0	165.0
Carpometacarpus	75.8	70.3	75.5	71.2	73.0	80.7
Ratios of lengths						
Tarsometatarsus to humerus	44.2	40.5	43.5	41.3	41.4	.....
Tibiotarsus to humerus	72.2	67.3	70.9	67.7	67.9	.....
Tibiotarsus to ulna	68.2	64.2	65.7	64.6	64.1	68.1
Tarsometatarsus to ulna	41.7	38.8	40.3	40.0	39.5	41.0(?)

[1] Maximum and minimum measurements and ratios from a series of 5 individuals; measurements of ulna and carpometacarpus for only 3 in the series.

[2] Measurements are from different individuals: tibiotarsus and ulna, bones from L.A. Co. Mus. skin no. 20735; carpometacarpus, bone from Mus. Vert. Zool. skin no. 69974; tarsometatarsi measured on skins, L.A. Co. Mus. nos. 20733 to 20735 (minimum) inclusive, and Mus. Vert. Zool. skin no. 69974 (maximum).

[3] Length of unpaired tibiotarsus, 116.1 mm.; estimated length of tarsometatarsus for this individual, 71 mm.

and Missouri, were borrowed from the U. S. National Museum. In spite of the fact that Dr. Herbert Friedmann very kindly selected the two largest specimens of this race from the collections, neither equals the cave bones in length of tarsometatarsus or tibiotarsus. In fact, one of the skeletons is generally smaller throughout than those of *P. a. albociliatus*.

Examination of five Alaskan skins of the northwestern race, *P. a. cincinatus* in the collections of the Los Angeles County Museum, compared with skins of *P. a. albociliatus* showed that the tarsometatarsi are longer in *P. a. cincinatus*. However, measurements of wing elements from the same skins were necessary to determine whether *cincinatus* exceeds *albociliatus* in length of all skeletal elements or whether the leg bones are longer in proportion to the wing bones as in the cave skeleton. Fortunately, one of the skins (no. 20735), from Prince of Wales Island, Alaska, was found to have a complete ulna and complete tibiotarsus that could be removed. These were compared with the cave specimens. They proved to be essentially identical in length with the comparable elements from the cave, and therefore to agree in proportion of tibiotarsus to ulna. The ulna from the skin, however, was found to be stouter than that of the cave specimen, particularly in breadth of the proximal cotylae and depth of the external condyle, distally. After several inquiries to other institutions, the only other skeletal specimen of *cincinatus* found to be available was procured from the Museum of Vertebrate Zoology. This is a carpometacarpus from skin no. 69974, collected near Vancouver Island, British Columbia. Mr. Richard C. Banks, who sent the specimen, kindly measured the tarsometatarsus from the same skin. In this instance, both carpometacarpus and tarsometatarsus are considerably longer than the paired elements of the cave skeleton, and slightly exceed the lengths that might be anticipated for the skeleton represented by the large, unpaired tibiotarsus.

These comparisons suggest that the ancient *Phalacrocorax auritus* of Nevada was more similar to the present northwestern population of the species than to that of either the west or central United States today. I would hesitate, however, to establish a Nevada record for *P. a. cincinatus* on the basis of the cave skeleton, particularly in view of the very scant Recent comparative material of that race that is now available.—HILDEGARDE HOWARD, *Los Angeles County Museum, Los Angeles, California, March 21, 1958.*

NOTES AND NEWS

We report with regret the death of Robert T. Moore on October 30, 1958. He was a member of the Board of Governors and Honorary Member of the Cooper Ornithological Society.

In connection with the preparation of accounts for the A. C. Bent series of "Life Histories of North American Birds," Wendell Taber requests information particularly on food habits and on behavior in general of Cassin's Sparrow (*Aimophila cassinii*), Black-throated Sparrow (*Amphispiza bilineata*), Sage Sparrow (*Amphispiza belli*), and the Black-chinned Sparrow (*Spizella atrogularis*). Such information may be sent to him at: 33 Lexington Avenue, Cambridge 38, Massachusetts.

The annual index for the Condor for 1958 was prepared by Mrs. Sylvia L. Thomssen. The editors as well as all members of the Society are again much indebted to her for this valuable assistance.

Awards for ornithological research are made in April of each year by the Frank M. Chapman Memorial Fund Committee of the American Museum of Natural History, New York. Applications should be received by March 15. Awards were made in 1958 for the following projects:

Edward Beals, University of Wisconsin: The ecology of the birds of the Apostle Islands.

Robert Ficken, Cornell University: The behavior of the Common Grackle, *Quiscalus quiscula*.

William George, University of Arizona: The significance of the hyoid bones in classifying birds.

Maria Koepcke, San Marcos University, Lima, Peru: A study of the Peruvian collections of birds at the American Museum of Natural History.

Nancy McAllister, University of Michigan: The reproductive ethology of the Pied-billed Grebe.

J. D. Macdonald, British Museum: A study of the bird collections at the American Museum of Natural History.

John Rogers, University of Missouri: The breeding biology and behavior of the Lesser Scaup.

Glen Sherwood, Utah State University: The relationship of the Whistling Swan to other waterfowl in the Great Salt Lake Valley of Utah.

Brenda Sladen, Johns Hopkins University: The respiratory system of birds.

COOPER SOCIETY MEETINGS

NORTHERN DIVISION

APRIL.—The regular meeting of the Cooper Ornithological Society, Northern Division, was held on April 10, 1958, in room 2503, Life Sciences Building, University of California, Berkeley. Dr. A. Starker Leopold presided.

The guest speaker was Dr. Walter E. Howard, University of California, Davis, who lectured on "New Zealand, Its Fauna and Scenery."—ROBERT I. BOWMAN, *Secretary*.

MAY.—The regular meeting of the Cooper Ornithological Society, Northern Division, was held on May 1, 1958, in room 2503 Life Sciences Building, University of California, Berkeley. Dr. John Davis presided. He reported briefly on the Annual Meeting of the Society just concluded in Salt Lake City, Utah. About 125 people were present. Dr. Davis announced that the Board of Governors elected Mrs. Junea W. Kelly to Honorary Membership in the Society.

The following observations were reported: Mr. Alan Craig observed over 200 Lewis Woodpeckers in Napa County on April 19. Many of these were "flycatching" in the oaks; Mr. Howard Cogswell also reported a flock of Lewis Woodpeckers, composed of about 15 individuals, at the foot of Mt. Diablo on April 12.

The guest speaker was Dr. Francis C. Evans of the University of Michigan, who spoke on "A Population Study of Color-banded Vesper Sparrows in Southeastern Michigan."—ROBERT I. BOWMAN, *Secretary*.

OCTOBER.—The monthly meeting of the Cooper Ornithological Society, Northern Division, was held on October 2, 1958, in room 2503, Life Sciences Building, University of California, Berkeley. The following names were proposed for membership: Dr. Peter R. Marler, Berkeley, by Dr. John Davis; Mr. Jerry Buzzell, Los Altos, by Dr. F. A. Pitelka.

Two motion pictures of the Machris Brazilian Expedition from the Los Angeles County Museum were shown.—ROBERT I. BOWMAN, *Secretary*.

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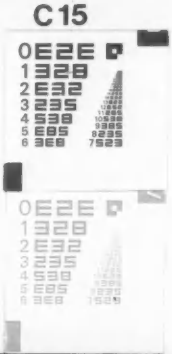
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